PROCEDURES FOR APPLYING BREAK-EVEN ANALYSIS AND REPLACEMENT THEORY TO FEED DELIVERY OPERATIONS

by

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CHAPTER I

INTRODUCTION

Technological advances currently being achieved in agriculture are unlike those of any other period in history. The formula feed segment of this industry could certainly be identified as one of the leaders in the "Agricultural Movement." Due to the efforts of scientists in the fields of feed nutrition, production, and technology, livestock and poultry feeders have been able to offer American consumers the world's best diet.

As feeders have increased and expanded their feeding operations, feed dealers and manufacturers have strived to fulfill their demands for low priced, high quality feed. The costs incurred in meeting these requests, particularly with respect to those involving delivery service, provide the foundation for the writing of this thesis.

Problems related to the delivery of mixed feeds have kept pace with the growing formula feed industry. As early as 1894, Ralston Purina, the nation's largest producer of formula feeds, was finding it profitable to deliver horse and mule feed along the Mississippi River and to the plantations and logging camps in the South.[1] Early feed deliveries were made by either train, boat, or wagon, and not until the "late 1920's and early 1930's" was feed shipped by motor truck.[2] With the introduction of improved motor carriers, the feed industry was able to expand throughout

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[1]Robert W. Schoeff, "The Formula Feed Industry," Feed Production Handbook (Kansas City, Mo.: Feed Production School, Inc., 1961), p. 11

[2]*Ibid.*

the nation. No longer is feeding limited to the areas where feed is produced (see Figure 1). Other factors such as climatic conditions, labor availability, and consumer concentration can be considered since the distributing of feed over long distances has been made possible by modern delivery equipment.

Robert W. Schoeff gives the main reasons for the increased use of delivery trucks when he writes that:

> During the past 15 years, as the feed industry has decentralized, smaller plants have been built closer to the customer. Ingredients and finished feed moved shorter distances and trucks offered the convenience, timeliness, and flexibility needed for moving these items at costs comparable to rail rates. Improved major and secondary roads, along with better trucks, contributed much to the switch from rail transportation. The desire of the manufacturer to be of greater service caused many to invest in their own fleets of trucks.[1]

Large feed manufacturers have always been confronted with the question of how they could reduce the cost of delivering mixed feed to retail outlets. Recently, however, the problem of distribution analysis has been extended to retail dealers and suppliers of special feed ingredients. The introduction of modern bulk delivery equipment in the middle 1950's has forced local feed dealers to purchase one or more feed delivery trucks. The advent of large commercial feed lots during the last decade has offered feed manufacturers a profitable market. In many cases feed producers have found that it is more economical to deliver directly to the large feeders and by-pass the local dealer; this increases their need for delivery equipment. The increased amount of mixing that is done on the farm and at the feed lot has opened a direct market for sellers of special feed ingredients. Figure 2 depicts the various markets that feed

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[1]Schoeff, p. 11.

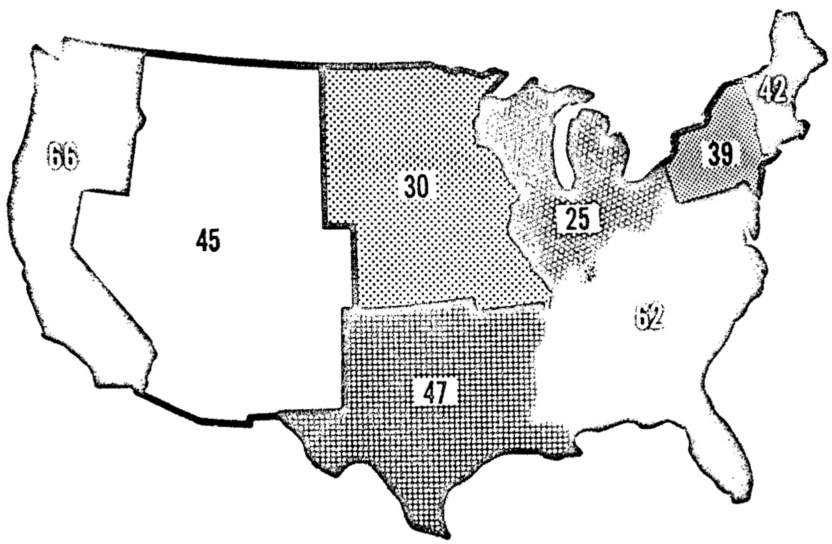

Fig. 1.--Percentage of commercial formula feed that was handled in bulk in 1961. Average for U.S. was 45%.[1]

[1]Oakley M. Ray, "Feed Industry Expansion Continues," <u>Feed Age</u>, XII, No. 12 (December, 1962), p. 48.

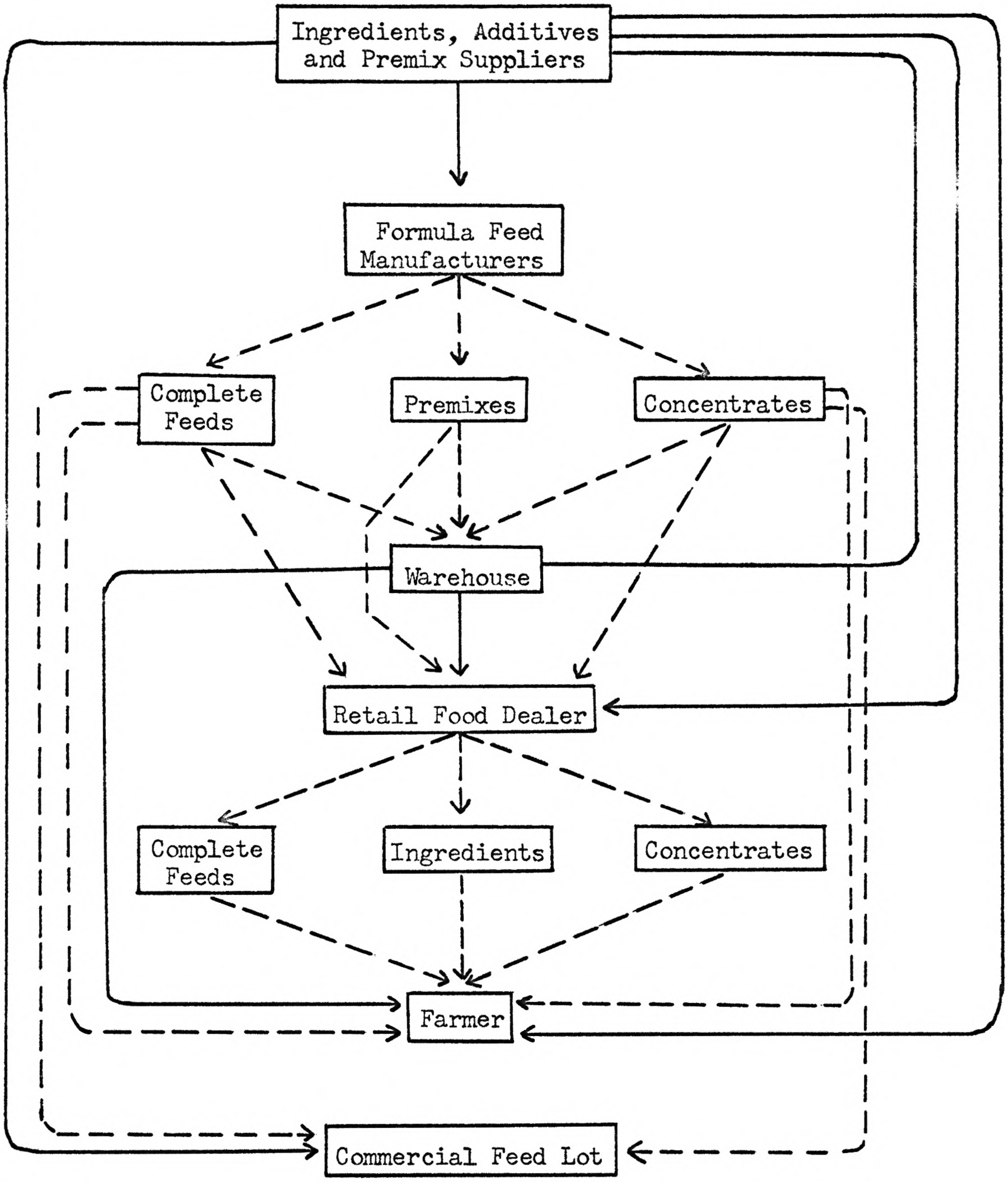

Fig. 2.--Market structure of the commercial formula feed industry.[1]

[1]Schoeff, p. 17.

and feed supply distributors may enter. It is not at all unusual for all three groups - the special ingredient supplier, feed manufacturer, and retail dealer - to be competing for the same feeder's dollar. The figure also illustrates that it is possible for the feed manufacturer to sell directly to the farmer and commercial feeder. This is more than a mere possibility, however, because feed firms are actually finding it more profitable to locate near the area they serve. In previous years suppliers of feed ingredients and additives found it necessary to schedule deliveries to only a small number of feed manufacturers. Today they must also determine how to best serve the retail dealers, small independent feeders, and large commercial feeders; all of whom may be manufacturing their own feed.

Figure 3 illustrates two facts that show why least-cost feed delivery is important today: (1) an increased number of retail dealers are having to deliver feed to their customers, as is shown by the increasing amount of feed that is sold in the bulk form, and (2) sales of sacked feed have tended to hold their own since 1960 which indicates feed manufacturers are having to maintain their bagged delivery along with their bulk distribution. The total amount of manufactured feed that was sold in bulk form increased from 13.89% in 1957 to 44.32% in 1962. Assuming the majority of bulk feed is delivered either to the retailer or directly to feeder and that the greatest portion of sacked feed is delivered at least once, it is seen that feed distribution is a major problem at all levels of the formula feed industry.

Ed Dickey, President, Honegger's and Company, brought out how important the reduction of feed delivery costs will be in the future when he stated, "more feeds are going to be delivered in bulk - at

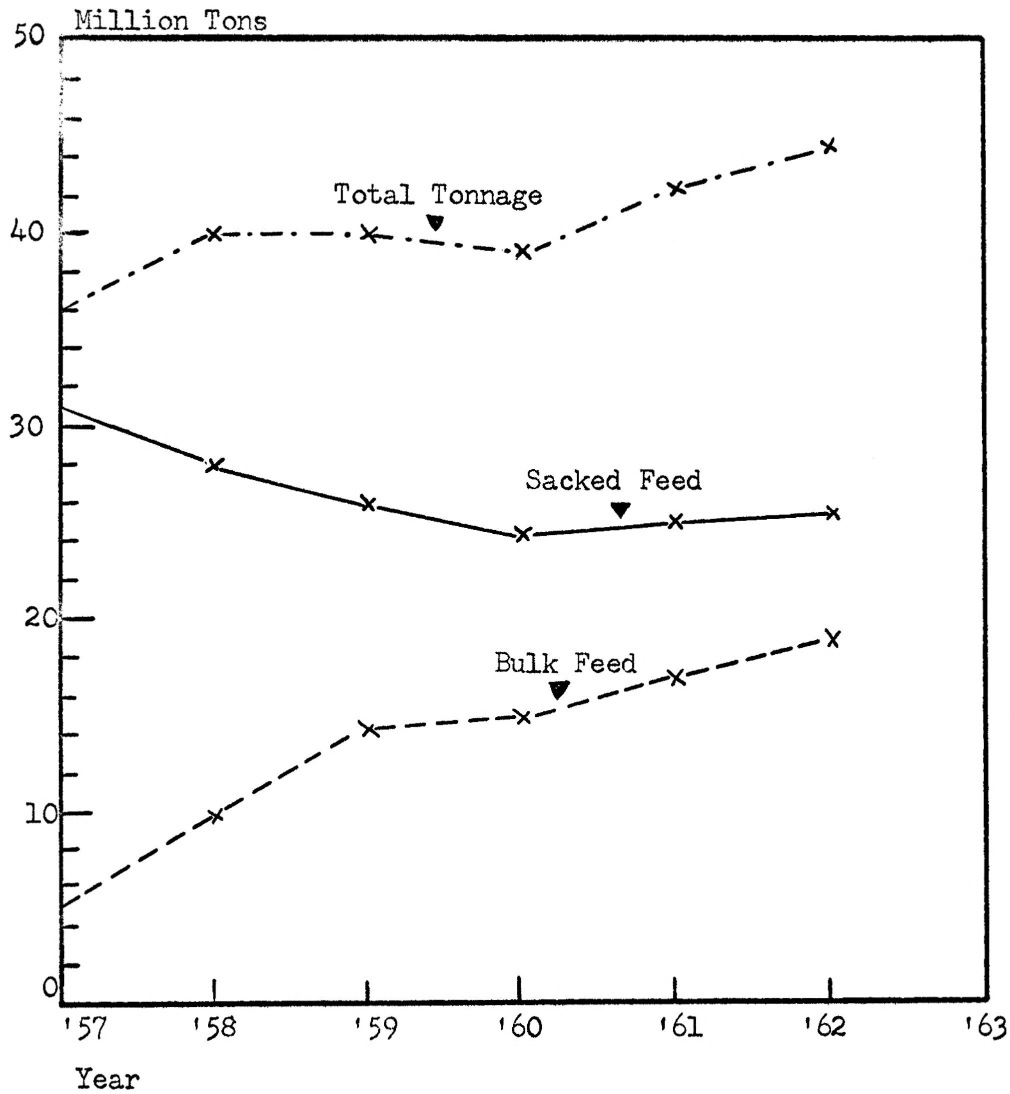

Fig. 3.--Feed tonnage sold in bulk and sacks.[1]

[1]Jerry Karstens, "Feed Trends - Bulk vs. Bagged," Feed Age, XIII, No. 4 (April, 1963), p. 48.

narrower margins - than we ever dreamed possible."[1] It is in this area of intensive delivery competition that the methods discussed in this thesis should be of most help.

The purpose of this paper is to show how two managerial tools - break-even analysis and replacement determination - can be adopted by feed distributing firms for helping to control their delivery costs. Break-even procedures, while based on assumptions of linearity, can be used to closely approximate the number of tons that will have to be hauled, over a specified number of miles, during a given period, and at a constant rate for the delivery operation to just pay for itself. Emphasis of this thesis has been on the development of a procedure whereby break-even analysis and replacement theory can be applied to the feed delivery operation.

In the majority of cases hypothetical data was used. However, the feed delivery cost study currently being conducted by Leonard W. Schruben of Kansas State University, did enable the author to use realistic cost figures. It was felt that no conclusive evidence could be derived by applying break-even analysis and replacement formulas to the data obtained by the Kansas State study since it had been received for only two months. It is evident from the data that has been received, however, that there is a definite need for additional cost control systems in the feed delivery department of many feed manufacturers. When similar firms are compared and their costs for delivering a ton of feed varies as much as sixteen dollars per unit, there is need for cost control systems.

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[1]"Editorial," <u>Bulk Feed & Grain</u>, June, 1963, p. 6.

CHAPTER II

BREAK-EVEN ANALYSIS APPLIED TO FEED DELIVERY OPERATIONS

Definitions and Assumptions

Break-even analysis is an accounting and mathematical procedure used to study the relationships between profit, costs, revenue, and volume. The main function of this managerial tool is to locate the point where revenue is just sufficient to meet expenses. Although this point may be computed by either algebra or geometry, it is usually presented in the form of a break-even chart (see Figure 4). Irrespective of the manner in which the break-even point is obtained, the method of analysis will always depend on the accounting principle that revenue less variable costs less fixed costs equals profit.

Cost-volume-profit analysis is a part of the broader economic theory known as marginalism.[1] Proponents of marginal analysis maintain that a firm or industry has reached its most profitable point when marginal revenue equals marginal cost. Although this paper does not employ break-even analysis to determine optimum profits, it can be used in such a manner. This chapter presents procedures for determining the point at which delivery costs and revenue are the same. Howell and Teichroew point out that "it should be clear that the optimizing aspects of break-even analysis are simple marginalism."[2]

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[1] James E. Howell and Daniel Teichroew, Mathematical Analysis for Business Decisions (Homewood, Ill.: Richard D. Irwin, Inc., 1963), p. 85.

[2] Ibid., p. 86.

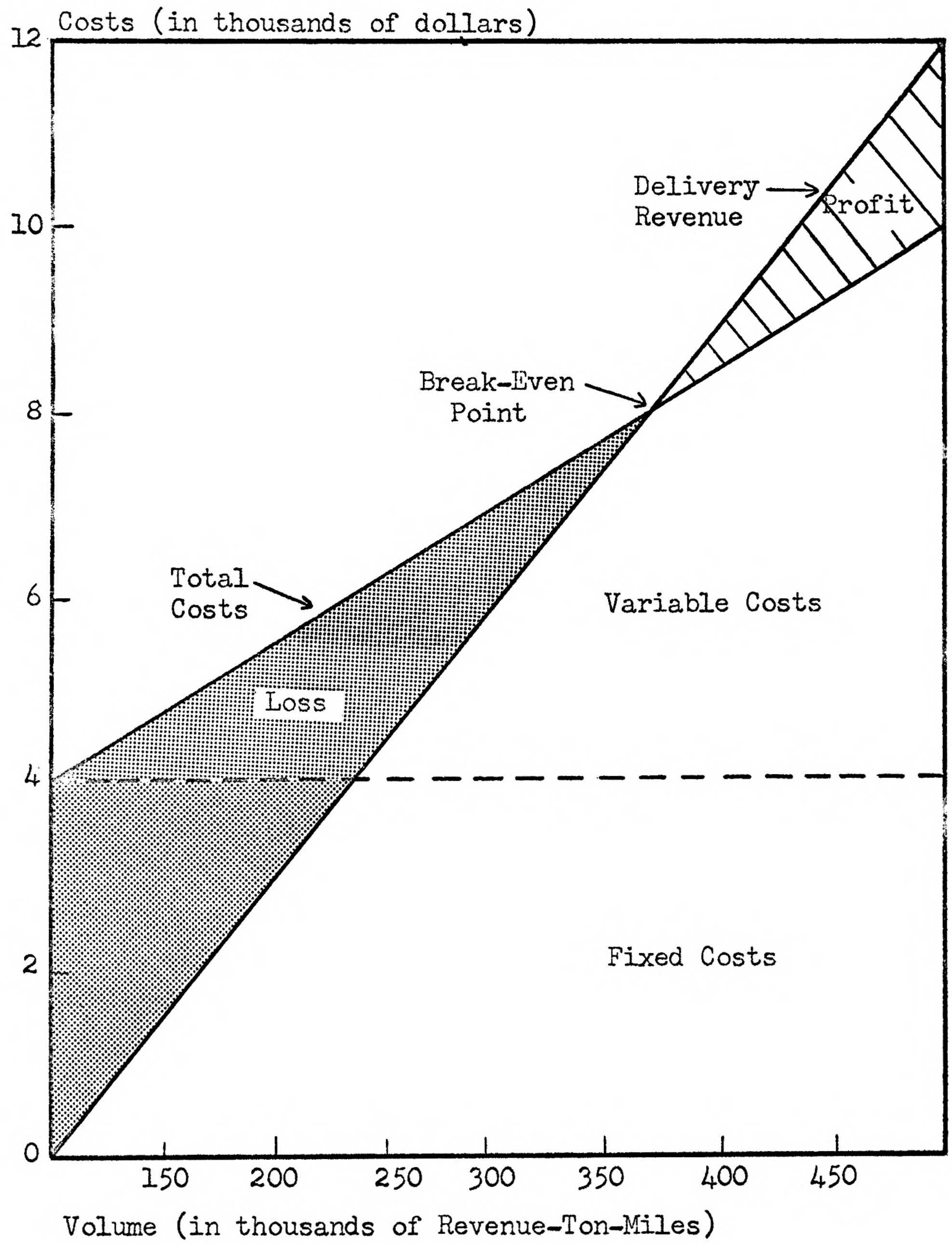

Fig. 4.--Simple break-even chart.

The basic concept underlying break-even analysis is that costs do not vary in proportion to revenue and even when there is no revenue forthcoming, certain expenses will be incurred. It must be understood that revenue increases or decreases bear no fixed relationship to cost changes and that there will be some fixed expense at all volume levels. It is usually conceded that costs will move in the same direction as revenue but at different rates. Fred V. Gardner explains this occurrence by writing that when sales mount, costs generally go up, but when sales level off and decline, costs do not follow quite so easily.[1]

Generally break-even analysis is presented in such a manner that it is applicable to the firm's entire operation. That is, it illustrates where total revenue and total costs are equal and at what unit of sales this equality will occur. The object of this chapter is to show how cost-volume-profit analysis can be applied to the delivery department of a feed manufacturing firm. The items of main concern are the total delivery costs at various levels of revenue-ton-miles and the volume at which revenue obtained from delivery is just sufficient to cover delivery expenses. Whatever the size of operation or the number of trucks in the fleet, break-even analysis can be applied to provide valuable information to management. It must have an elementary knowledge of algebra or geometry, must maintain adequate records, and must have a desire to know at what volume their delivery service pays for itself.

Raymond W. Andrews, Comptroller for a large Connecticut plastic pipe corporation, explains why break-even analysis is important to all industries when he writes:

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[1]Fred V. Gardner, "Breakeven Point Control for Higher Profits," Harvard Business Review, XXXII, No. 5 (September-October, 1954), p. 123.

> It is significant that break-even analysis is a feasible approach for industrial accountants to introduce to management or to increase its usefulness in managerial deliberations, to aid in planning and cost control. Neither its preparation nor its use need be time consuming for either the accountant or management. In fact such presentation, well-done, may supercede detailed reporting already being furnished, thus eliminating time-consuming duties rather than adding them. Profits can be predicted and a program for determining the effect of volume on these profits becomes well worth while.[1]

The value of applying break-even analysis to feed delivery operations largely depends on its underlying assumptions. The main assumptions are:

(1) Fixed costs will remain rigid and constant over all levels of delivery and variable costs will vary in direct proportion to the amount delivered. This is a sound assumption when a rather short period is considered. That is, the term in question should permit fluctuations in operating costs but should not be long enough to allow for fluctuations in capital outlays. If any longer period were considered there is the possibility that fixed costs would vary due to increased or decreased demand for feed, and economic conditions might change such that the relationship between variable costs and volume might not always be the same. In assuming this direct relationship, analysts are essentially saying that variable cost will increase at a specified rate when units of volume are added. Even though no actual data is presented in this thesis to uphold this assumption, it

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[1]Raymond W. Andrews, "Why Not Use the Break-Even Chart More Freely?" National Association of Cost Accountants Bulletin, XXXVIII, No. 6 (February, 1957), p. 782.

appears that it is realistic when other studies are reviewed which are based on actual cost and volume records.

Paul L. Kelley explains that:

> consequently in this analysis a linear extrapolation of cost functions derived from the can milk trucks was made on the judgment that the linear functions would apply in the operating range of the bulk trucks. . . . an equation of the form $Y = a+b_1x_1+b_2x_1^2$ provides a better fit than the equation $Y = a+bx$ used here. However, the extra complications of the use of the above function did not appear justified in view of the minor importance of this cost item in the analysis.[1]

Other studies which can be cited for their assumption that variable costs are a linear function of delivery volume are in the articles by Seaver[2] and Clarke.[3]

(2) Total costs can be separated into fixed or variable costs. Also assumed, concerning costs separation, is the concept that all semivariable expenses (telephone, supervisory, etc.) can be divided into fixed and variable proportions. Procedures that would enable a feed distributor to partition his costs, both graphically and mathematically, are presented in another section of this thesis.

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[1]Paul L. Kelley, Cost Functions for Bulk Milk Assembly in the Wichita Market (Technical Bulletin 96) Manhattan, Kan.: Kansas State University, May, 1958, p. 32.

[2]S. K. Seaver, The Effect of Variability in Supply of Eggs Upon Wholesale Marketing Costs (Bulletin 331) Storrs, Conn.: University of Connecticut, April, 1957, p. 6.

[3]D. A. Clarke, Jr., Milk Delivery Costs and Volume Pricing Procedures in California (Bulletin 757) Berkley, Calif.: University of California, December, 1956, p. 58.

(3) Rate charged for delivery will not change with increased or decreased volume. This assumption has to be made in order to have a linear revenue function. It is absurd to think that feed dealers will not charge a lower rate when volume has increased or vice-versa when volume decreases. The ideal situation would probably be to construct a revenue curve that shows the relationships between varying delivery rates and changing volumes. But as Mr. Paul Yacobian, Staff Accountant for The Gabriel Company of Cleveland, Ohio, explains, when the revenue function is drawn as a curve then the theory of price determination and its expected results are involved.[1] Figure 5 gives an illustration of how linear revenue functions can be utilized to show the affect rate changes will have, or what the rate should be when volume varies. If the manager forecasts his volume to decrease, say from 260,000 revenue-ton-miles (r.t.m.'s) to 173,000 r.t.m.'s then, as the break-even chart indicates, he should raise his delivery charge from 4.19 cents to 4.97 cents per r.t.m. This gives the feed distributor a method of predicting the effect rate and volume changes will have over an extended period. But, as previously indicated, the linear function cannot show the effects on cost and volume when the rate varies within the specified period.

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[1]Paul Yacobian, "A Practical Evaluation of Break-Even Analysis," National Association of Accountants Bulletin, XL, No. 5 (January, 1959), p. 24.

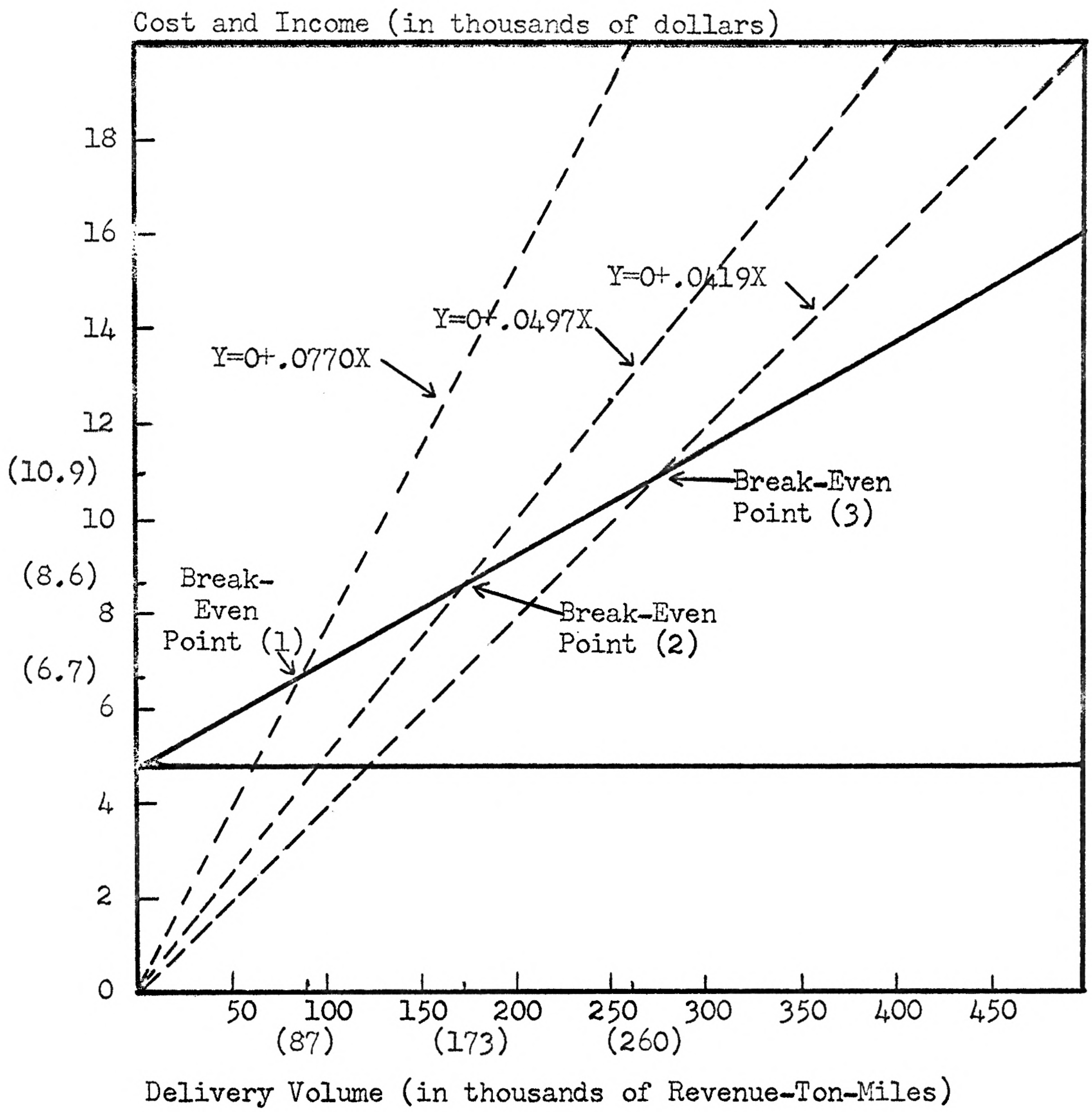

Fig. 5.--Break-even points at various delivery rates.[1]

[1]Cost data corresponds to that derived in Table 4.

(4) Truck "mix" will be constant. It is realized that there will be times when the more expensive operating trucks will have to be used and other times when they will sit idle. But the relationship between the amount of time costly trucks are used as opposed to operating less expensive trucks will remain about constant. Granted all trucks may not be used the same, but they most likely will be used in about the same proportion.

(5) The general price level will not vary. If any economic changes occur which force the firm to alter its delivery rate then a completely new break-even chart must be constructed.

Before a decision maker prepares a break-even chart or changes any policies due to information gained from break-even analysis, he should thoroughly understand the basic assumptions discussed above and should be realistic as to how much information he can obtain by the use of this method. Yacobian points out that "since it is impossible to show a sales line on a break-even chart when the prices, product mix, or variable cost ratios change the chart is generally an analysis of sales and costs over a period short enough for their factors to be assumed to be constant."[1]

Establishing A Cost Basis

An appropriate cost measure must be selected before cost-volume-profit analysis can be initiated. This writer has concluded that delivery costs related to revenue-ton-miles will give a more realistic description of delivery expenses than any other proposed method. Merill J. Roberts

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[1] Ibid.

writes in Land Economics that the use of revenue-ton-miles is permissible if the trucks are carrying a homogeneous product.[1]

What is wrong with expressing delivery costs in terms of tons, miles, or ton-miles? First of all, the validity of a ton or mile basis will depend largely on the location of the customers being served. When two firms are compared - one that uses a ton basis and one that uses a mile basis - it can be shown that both could increase their returns if they switched to a r.t.m. standard. The distributor who charges according to the number of tons hauled can maintain a profitable business if he serves only customers that are located relatively near his plant. Assuming this firm delivers feed to all customers at the same rate, his hauling expenses will be higher for the longer delivery routes. Following the same line of reasoning it is seen why the dealer who charges according to miles has higher costs and fewer returns when he has to make short hauls. Since distance and volume are the main determinants of expense in delivery operations, and the expression of one without the other may prove to be invalid, the author has chosen to state them as one unit - revenue-ton-mile.

Table 1 illustrates why r.t.m.'s are a more precise measure than ton-miles when delivery operations are concerned.

Ton-mile computations assume the entire load is carried the complete distance. In the following table, the 11 tons can be multiplied by the total miles driven or the miles between stops and then summed; either method gives a total of 671 ton-miles.

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[1]Merill J. Roberts, "Some Aspects of Motor Carrier Costs: Firm Size, Efficiency, and Financial Health," Land Economics, XXXII (August, 1956), p. 229.

TABLE 1

COMPARISON OF REVENUE-TON-MILES AND TON-MILES

Place of Departure	Destination	Tons Hauled	Miles Driven	Ton-Miles	Revenue-Ton-Miles
A	B	11	5	55	55
B	C	9	15	165*	135
C	D	5	11	121*	55
D	E	3	14	154*	42
E	A	0	16	176*	00
(11 x 61 = 671)		11	61	671	287
	Estimation of r.t.m.'s 28 ÷ 5 x 61 = 342				

*Eleven tons multiplied by the corresponding number of miles driven.

Revenue-ton-miles, on the other hand, pertain to the actual number of miles each ton was carried. By using a r.t.m. basis a distributor can determine the effects of undercapacity and insufficient backhauls.

If, in the example, the dealer could have arranged for a six ton backhaul from E to A, his r.t.m.'s would have increased ninety-six units or his total r.t.m.'s would have been 351. If his margin of revenue over cost was .015 cents per r.t.m., the backhaul would have netted him $1.44 or he would nearly have broken even. If there had been no backhaul and truck operating costs were three cents per r.t.m., the firm would have lost a total of $2.88, or its return per mile would have been -.18 cents. This figure may seem only minor, but it must be remembered that this was only one delivery route; and if it was driven five days a week, the loss due to running empty would be $14.40 per week, $61.92 per month (4.3 weeks in a month) or $743.04 per year.

Table 1 also shows the proper method for calculating r.t.m.'s. The tons must be broken down to show the actual number of miles they were hauled. R.t.m.'s would have been equal to ton-miles in Table 1 only if the eleven tons had been carried sixty-one miles. Another principle which must be pointed out is that total miles multiplied by total tons will give total ton-miles but not total r.t.m.'s. The basic reason for using a r.t.m. measure will be ignored if totals are used for computations. The quantity desired is one that denotes the number of miles that feed is actually hauled.

If a quick estimate of r.t.m.'s is needed, the feed dealer can do as shown in Table 1. Tons hauled between destinations can be added and then divided by the number of destinations to give an average tonnage hauled between delivery points. This times the total number of miles driven will give an approximation of r.t.m.'s. But it must be remembered that the estimate discrepancy will become larger as the size of numbers increase. It would seem likely that feed distributors might use this process of estimation, rather than setting up a record keeping system that would determine the exact r.t.m.'s. In the opinion of this writer the estimation would probably suffice where the delivery routes vary from day to day, but actual r.t.m.'s should be required when delivery routes follow a set pattern.

Separation of Costs

A prerequisite for using break-even analysis is a bookkeeping or accounting system that enables management to separate total costs into its fixed and variable components. Placing of costs in their correct classification may prove to be very difficult and some firms may be required to alter their record keeping system. Leonard W. Schruben presents a method designed especially for truck delivery operations that could serve as a model for firms that need more adequate records (see Figures 6, 7, and 8). Figure 9 is a procedure offered by Raymond W. Andrews for determining fixed and variable costs. The Information Chart for Feed Delivery Break-Even Analysis presented in Figure 10 illustrates the data that a firm will need before the analysis prescribed in this thesis can be applied. The specific items are explained as they are incorporated into the procedure.

In order to separate costs the delivery operation must be considered in the short-run period. As Leftwich points out, there are no fixed costs in the long-run, "all resources are variable."[1] In terms of calendar time the short-run period for delivery firms is rather short when compared to other industries. The Bureau of Transport Economics and Statistics must be presuming that the short-run for truck delivery firms is relatively the same length as terms for other industries, such as railroads, when it states that no more than ten per cent of total delivery expenses can be classified as fixed.[2] The Bureau is basing its statement on the belief that the majority of delivery equipment and facilities can be adjusted according to the volume of business done. Their view seems to be based on a short-run period that is rather long when compared with views of other transportation economists. Locklin indicates that in the short-run, fixed delivery costs comprise much more than ten per cent when he writes:

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[1]Richard H. Leftwich, The Price System and Resource Allocation (New York: Holt, Rinehart, and Winston, 1955), p. 141.

[2]David Philip Locklin, Economics of Transportation (5th ed. rev.; Homewood, Ill.: Richard D. Irwin, Inc., 1960), p. 644.

ENROLLMENT SHEET FEED TRUCK DELIVERY COST STUDY Firm________________ Truck no._________ Location_____________ License no._______	INSTRUCTIONS: The information requested here is to enable a more accurate calculation of costs. It will be filled out only once for each truck. When a new truck is acquired, an enrollment sheet should be sent in for that truck.

Truck Description: Make_____ Model_____ Year_____ Rated size (tons)____

Used primarily for delivery of: (check one) bulk____ sacked____ both____

Estimated speedometer reading January 1, 1963 __________

Compartments: No. of compartments _____ Size of each in cubic feet_____

Tires: No. of tires ________ Size _______ Ply _____

Do you replace with: (check one) new_____ recap _____ both _____?

Type of fuel used: (check one) gasoline ____ diesel _____

DEPRECIATION SCHEDULE

Item	Date of purchase	Initial cost	Estimated actual life in use (years or mileage)	Book value Jan. 1, 1963	Estimated book depreciation calendar year 1963
Truck chassis......					
Bed...............					
Tires, new.........					
Tires, recap.......					
Supplemental equipment (specify):					
__________					
__________					

Fig. 6.--Truck identification and initial information form.[1]

[1]Form devised by Leonard W. Schruben of Kansas State University, Manhattan, Kansas.

Firm____________________ Truck no. __________ Month__________

Day	Speedometer end of day	Miles driven	Gallons fuel	Hours truck on delivery	Tons delivered	Tons backhauled	Trips made	Delivery stops
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
Total..........								

Fig. 7.--Form for recording daily truck costs.

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Firm ____________________ Truck no. _______________ Month _______________

INSTRUCTIONS

Use a separate card for each truck for each month. Use the same number for same truck in subsequent months.

EACH DAY: Use reverse side to record at end of day the indicated data. One line is provided for each day.

1. Speedometer reading at end of day.
2. Total miles driven during day for all purposes.
3. Gallons of fuel added to tank during day.
4. Hours spent by truck on feed delivery. Include time spent going and returning to plant. Exclude time spent loading and unloading at plant.
5. Tons of feed delivered to customers.
6. Tons backhauled. Include feed, grain, purchased supplies, or other material returned to plant or delivered to another point as part of the firm's operations.
7. Number of trips made.
8. Number of stops made to deliver feed.

EACH MONTH: Use this side of card to record all costs directly incurred in the operation, maintenance, or repair of truck (including tires and bed) which can appropriately be charged to this month's expense. Exclude costs not part of delivery cost in month covered.

If costs apply to more than one truck, to activities other than feed delivery, or to more than one month, allocate such costs on a reasonable basis so that all operating costs of truck but only the operating costs during month are included.

Wages - Driver. Gross wages of all who drove this truck. If less than full-time, pro-rate on basis of proportion of total work time spent on delivery. See other side of card for hours on delivery.

Wages - Helper. Pro-rate on same basis as driver.

FICA and other labor costs. FICA, unemployment compensation, workmen's compensation, health insurance.

Fuel cost. Cost of gasoline or diesel fuel used.

Oil, grease, and antifreeze used.

Tire repair. Include all repairs as they occur but do not include recapping or replacements.

Painting and washing.

Garage supplies. Soap, waste, hoists, jacks, etc.

Taxes - Use and special. Include ton-mile taxes and all special taxes incurred in operating truck.

Bridge and road tolls. Turnpike tolls, bridge tolls.

Repairs - by plant - Labor. Estimated cost of labor spent by employees of the firm in repairing truck.

Repairs - by plant - Parts, etc. Include all parts and materials used in repairing truck in plant shop.

Repairs - by outside shops. Total cost of repairs by outside shops.

Truck rental. Rental fee for month covered.

Garage rental. Rental fee for month covered.

Insurance. Include all insurance payments covering liability, property damage, collision, fire, and theft.

Taxes (Property). Property tax on truck.

License fees. Include State license fees. ~~chauffer's~~ licenses (if paid by firm), city licenses, all permits.

Depreciation on bed, chassis, and tires, and interest on investment will be computed from information on enrollment card, which is filled out only once.

Other. Enter any costs not included in above.

Each month return completed cards to Grain and Feed Marketing Research, Dept. of Economics and Sociology, Waters Hall, Kansas State University, Manhattan, Ks.

FEED TRUCK DELIVERY COSTS

Wages - Driver..............	$
Wages - Helper...............	
FICA and other labor costs....	
Fuel cost..................	
Oil, grease, and antifreeze..	
Tire repair	
Painting and washing........	
Garage supplies............	
Taxes - Use and special.....	
Bridge and road tolls.......	
Repairs - by plant - Labor...	
Repairs - by plant - Parts, etc.	
Repairs - by outside shops...	
Truck rental...............	
Garage rental...............	
Other operating costs(specify):	
________________	
________________	
________________	
Fixed costs chargeable to this month:	
Insurance.............	
Taxes (Property).......	
License fees...........	
Other (specify):	
________________	

Check here if you:

a. Sold or traded chassis ☐

b. Bought new tires ☐ recapped tires ☐

c. Replaced bed ☐

d. Added other equipment ☐

Fig. 8.--Form for recording monthly truck costs.

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Item	Expenses	
	Fixed	Variable
Driver's wages		X
Helper's wages		X
Additional labor cost		X
Overhead		X
Fuel and lubricants		X
Tire repair		X
Body care and maintenance		X
Garage supplies		X
Use tax		X
Bridge and road tolls		X
Repairs - if not guaranteed maintenance		X
Repairs - if guaranteed maintenance	X	
Truck rental - yearly rate	X	
Truck rental - rate based on miles used		X
Garage rental		X
Insurance - liability, group, and compensation	X	
Taxes, property	X	
License fees	X	
Depreciation, mileage		X
Depreciation, years	X	

Fig. 9.--Delivery expenses classified as fixed and variable.

<u>General Data</u>

1. Number of Trucks ____
2. Net Delivery Revenue ____
3. Revenue-Ton-Miles Driven ____
4. Rate Charged for Delivery ____
5. Revenue-Ton-Miles of Backhaul ____

<u>Revenue-Ton-Mile Data</u>

6. Tons hauled ____
7. Miles driven ____
8. Trips made ____
9. Steps made ____
10. Stops per trip (10÷9) ____
11. Miles per trip (8÷9) ____
12. Tons per trip (7÷9) ____

<u>Costs Data</u>

Fixed Costs:
- Depreciation (yearly basis) ____
- Insurance ____
- Property tax ____
- Truck rental ____
- Repair & maintenance (if guaranteed maintenance program) ____
- License fees ____
- Other ____
- Total ____

Variable Costs:
- Labor, direct ____
- Labor, indirect ____
- Fuel and lubricants ____
- Tire repair ____
- Body care and maintenance ____
- Garage supplies ____
- Tolls ____
- Depreciation (mile basis) ____
- Truck rental (mile basis) ____
- Other ____
- Total ____

Semivariable Costs:
- Garage rental ____
- Telephone ____
- Overhead ____
- Supervisory ____
- Other ____
- Total ____

Fig. 10.--Information chart for feed delivery break-even analysis.

> In the short-run, however, motor carriers have a substantial proportion of their costs fixed or constant. This can be seen by considering the case of an individual who undertakes to engage in for-hire transport with only one or two vehicles. If he finds it difficult to obtain business, he is tempted to take any business that he can get at a cut-rate price, which may be a price that will give him some revenue above gasoline and oil costs and any other immediate outlay. Under these circumstances he recognizes that interest on investment in vehicles, property taxes on the vehicles, motor vehicle registration fees, and at least part of the depreciation on the vehicle are fixed costs and are incurred whether he moves any traffic or not. Short-run variable costs rather than long-run variable costs will determine what rate he charges.[1]

The confusion that exists seems to be due to the differences of opinion as to what constitutes the long-and-short-run. This thesis will follow an event sequence method for determining long-and-short-run terms rather than trying to designate a specific calendar period. The long-run period will begin when firms buy and sell motor carriers in relation to their volume of business.

Semivariable costs will also have to be separated into two components. This may prove to be the most difficult task in the costs separation process. How much of telephone and supervisory expenses are fixed and how much are variable? B. LaSalle Woelfel, of the Small Business Administration, explains that the dividing of semivariable costs can be done geometrically rather than being left to the discretion of someone merely because he has had many years of experience.[2] The first step involved when applying Woelfel's system is to relate the semivariable expense to some other variable expense, as is shown in Table 2.

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[1] *Ibid.*, p. 645.

[2] B. LaSalle Woelfel, *Guides for Profit Planning*, Small Business Administration, Small Business Management Series No. 25 (Washington: U.S. Government Printing Office, 1960), p. 10.

TABLE 2

TELEPHONE EXPENSE RELATED TO LABOR EXPENSE

Time Period	Labor Expense in thousands	Telephone Expense in thousands	Plotted Point
1st 2 months	8	4	A
2nd 2 months	9	5	B
3rd 2 months	11	6	C
4th 2 months	10	6.5	D
5th 2 months	5	4.5	E
6th 2 months	8.5	5.25	F
TOTAL EXPENSES	51.5	27.25	

After the semivariable expense (telephone) has been related to an easily calculated variable expense (labor), the different points can be presented in a scatter diagram such as Figure 11. After viewing the diagram, a straight line should be drawn as close to all points as possible.[1] The line should be extended to the point where it intersects the vertical axis. The intersection will denote the amount of fixed telephone expense. In order words, even if there is no feed delivered there will be a certain amount of telephone costs. Suppose the firm using the chart in Figure 11 had a telephone bill of $5,000 for the two months in question. Management can be relatively sure that they would have had a $1,500 telephone bill no matter how much feed was delivered. Company officials may also be interested in knowing the amount of telephone expense they can expect for each revenue-ton-mile driven. Assuming 600,000 r.t.m.'s driven

[1]The method of "least-squares" can be applied if more precision is desired.

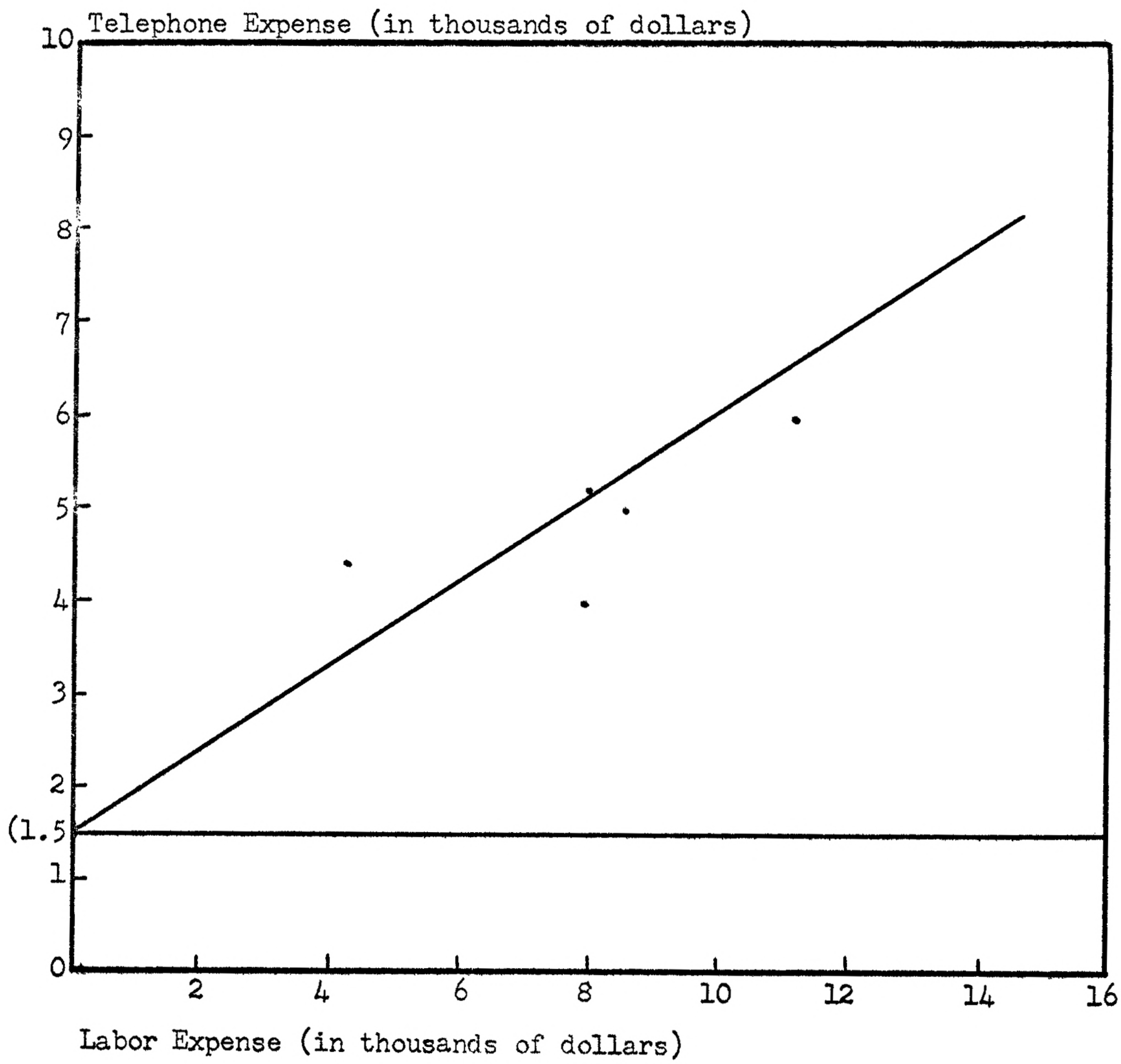

Fig. 11.--Scatter diagram used to separate semi-variable costs.

for a two month period, the variable telephone cost expressed per r.t.m. would be $3,500 ÷ 600,000 = $00.0058. Now if the management wants to estimate future telephone expense, they can do so by multiplying the forecasted r.t.m.'s times $00.0058 plus the $1,500 of rigid costs.

Many times management will want the semivariable expense expressed as a certain per cent of sales. In the case of delivery operations, variable cost can conveniently be stated in terms of a per cent of revenue derived from delivery. If in the above example, the firm had delivered feed for four cents per r.t.m., it would have received $24,000 from the delivery service for the two month's operation. Semivariable telephone expense can be expressed as a percentage of delivery revenue by dividing $3,500 by $24,000 which equals 14.59 per cent. Total telephone costs could be computed by the formula $1,500 + .1459 ($24,000) = $5,000.

The chief source for error in this method is in the drawing of the line of "best fit" on the scatter diagram. A more precise method for separating costs is the statistical procedure known as the "least-squares regression line." This follows from the simple linear regression equation, $Y = a+bx$, where Y is the dependent variable, a the fixed cost, b the variable cost per unit, and x the independent variable. As applied to feed delivery operations, Y would be the average total delivery cost which would be equal to the average fixed cost, a, plus the average variable cost per r.t.m., b, times the number of r.t.m.'s in question, x.

Allen W. Rucker, in the Harvard Business Review, describes the least-squares method of costs separation as a procedure for establishing standard ratios.[1] He also discusses the simple inspection method but discour-

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[1] Allen W. Rucker, "Clocks for Management Control," Harvard Business Review, XXXIII, No. 5 (September-October, 1955), p. 75.

ages its use due to its lack of precision. The procedure for applying the least-squares method to costs separation can best be explained by applying it to an everyday operation. Rucker maintains that the procedure for making coffee is similar to the regression method used in determining the proportion of fixed and variable costs.[1] When making coffee it is generally accepted that there should be one spoonful for the pot and one for each cup to be served; and two cups are usually allowed for each person. From this information the constants in the regression equation can be stated as: a = 1 and b = 2. The number of spoonfuls needed, Y, will be dependent upon the number of persons to be served. If coffee were being made for six persons, the number of spoonfuls that should be added would be: Y = 1 + (2 x 6) = 13. From this practical explanation it can be seen how important the a and b figures are in the regression equation. The analytical procedure for deriving values a and b will be given under the section: Statistical Correlation Analysis.

In Table 4, which is explained later, it can be seen that average fixed costs were found to be $4669 and variable costs averaged 2.32 cents per r.t.m. By linear regression a specific dollar value has been determined for fixed cost and the cost for each added r.t.m. is known.

Construction of Break-Even Chart and Table

The break-even chart is so called because it presents:

> a visual representation of sales volume, capacity, or output when expenses and revenues are equal; i.e., a volume at which income equals expense. It is a diagram of the short-run relation of total expenses and total income to output.[2]

Although the majority of articles pertaining to cost-volume-profit anal-

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[1] Ibid.

[2] Woelfel, p. 15.

ysis are augmented by graphic presentation, the data from which they are constructed are usually compiled algebraically rather than geometrically. However, if feed distributors are going to use break-even analysis, they must understand both methods of construction. Geometry offers the decision maker a simplified method for quickly setting up his model and estimating future costs and returns at various volumes of delivery. The more refined algebraic model, even though being more complicated than its geometric counterpart, allows management to insert data with substantial variation and still obtain precise results. Regardless of the procedure followed, the applier must have a full understanding of the limitations set forth by assumptions in the first section of this chapter. As assumptions are altered, break-even charts will give entirely different answers.

Geometric Procedure

To follow this method, the feed carrier must first have accurate information concerning his fixed and variable costs. The forecast profit and loss statement, illustrated below, may be one reliable source for costs information. A delivery income statement might also be used, but the validity of these types of information will depend largely on the accuracy of the accounting system in use.

To construct a break-even chart (see Figure 12) from the data presented in Table 3, the pattern followed might be as presented below:

(1) First, the measurement bases must be determined and then placed on their appropriate axes. In most instances costs and revenue are shown on the vertical axis while the horizontal axis has various titles. Examples of these titles are: "sales volume, units sold, per cent of capacity, direct

TABLE 3

PROFIT AND LOSS CALCULATIONS

	Variable	Fixed	
Net delivery revenue (300,000 r.t.m.'s @ 4 cents per unit)			$12,000.00
Less costs and expenses:	Variable	Fixed	
Labor	$4,000.00		
Fuel & lubricants	2,000.00		
Maintenance & repairs	1,800.00	$ 200.00	
Insurance & taxes & license	50.00	400.00	
Overhead	800.00	200.00	
Depreciation & interest on investment		2,000.00	
TOTAL	$8,650.00	$2,800.00	11,450.00
Forecast profit from delivery before taxes			$ 550.00

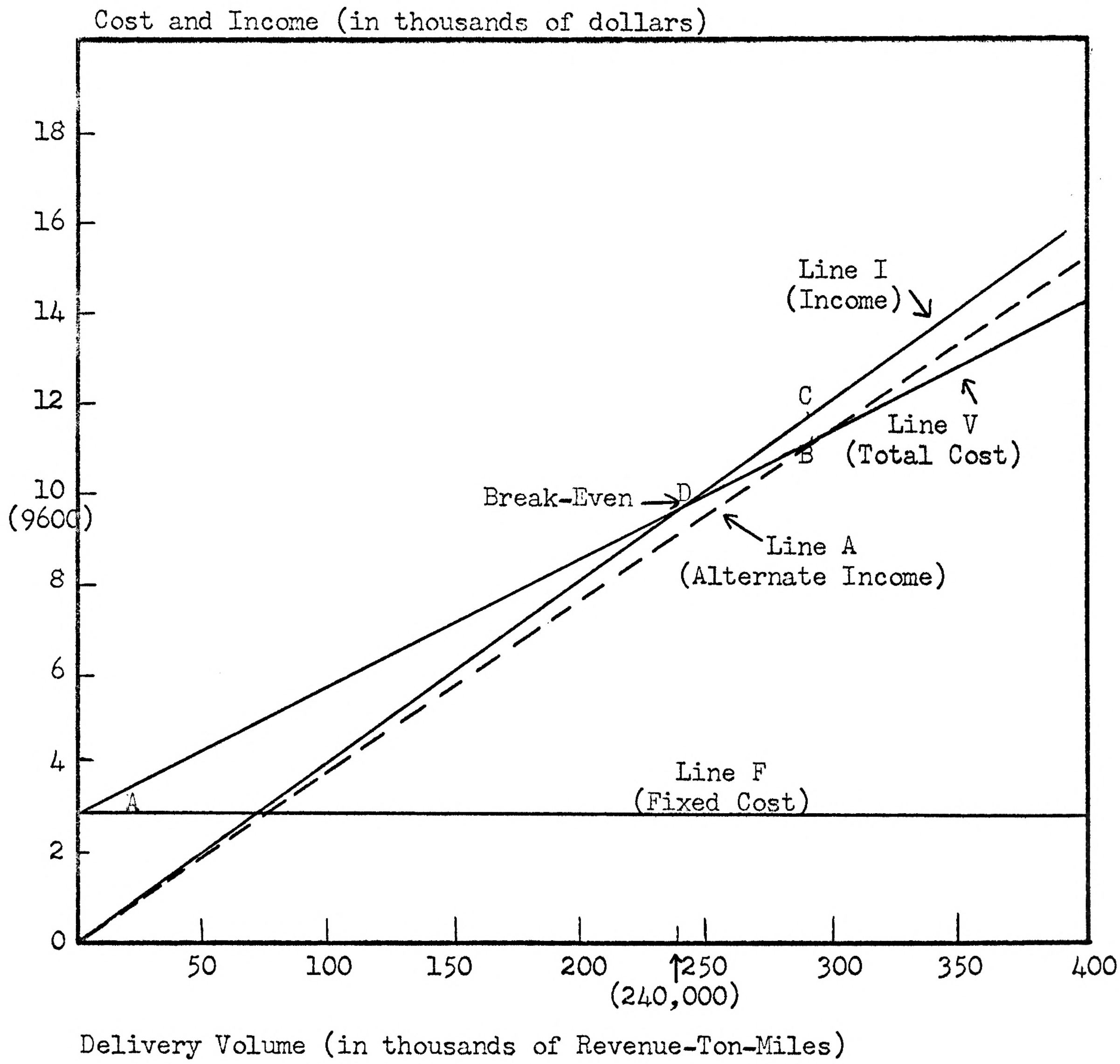

Fig. 12.--Geometric construction of break-even chart.

Source: Data from Figure 8.

labor hours" or as the writer of this thesis has chosen, revenue-ton-miles. In order to show fixed cost in accordance with the assumption that it is constant at all levels of output, a horizontal line should be drawn from the vertical axis at $2800.

(2) To indicate the average amount of variable cost per r.t.m., Line V must be constructed. The information in Table 3 illustrates that total cost will be $11,450 when delivery volume is 300,000 r.t.m.'s. Point B can be plotted by using these figures. A line through A and B will show what average total cost will be per r.t.m. and the distance between Line F and Line V will be the quantity of variable cost for each delivery unit. Total cost can be found by starting from the number of r.t.m.'s in question and extending upward until Line V is intersected. The value on the vertical axis corresponding with this point will be the amount of total cost. This amount less $2800 will equal the quantity of variable cost for the specified number of r.t.m.'s.

(3) Income Line I can be found by constructing a line from Point O through Point C. C's position is located by using the data in Table 3 which shows when 300,000 r.t.m.'s are driven at a rate of four cents per r.t.m. the revenue received will be $12,000. The break-even point, or where total cost equals total revenue, is at the intersection of Lines I and V denoted by D. By reading the values from the two axes which are relevant to Point D, management can locate their break-even point if conditions remain the same. At the cur-

rent delivery rate of four cents per r.t.m., feed delivery costs of $9600 are just covered at the level of 240,000 r.t.m.'s.

Table 3 shows that four cents were charged per r.t.m., but how can the feed deliverer calculate his costs? By computing the slope of Line V, the costs per r.t.m. can be determined. The formula for computing the slope of a straight line that passes through two points is:

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad [1]$$

Applying this formula to Line V costs can be found in the following manner:

$$A = (x_1, y_1) = (0, 2.8)$$

$$D = (x_2, y_2) = (240, 9.6)$$

$$m = \frac{\$9.60 - \$2.80}{240 \text{ r.t.m.} - 0} = \frac{\$6.80}{240 \text{ r.t.m.}} = \$00.0283 \text{ per r.t.m.}$$

After constructing a break-even chart such as Figure 12, feed distributors might decide that they can afford to charge a lower rate for delivery and break even at their average annual delivery volume of 300,000 r.t.m.'s. To compute the new rate, management can draw a line through O and B and then compute its slope as follows:

$$A = (0, 0)$$

$$D = (300, 11.45)$$

$$m = \frac{\$11.45 - \$00.00}{300 \text{ r.t.m.} - 0 \text{ r.t.m.}} = \$00.0381 \text{ per r.t.m.}$$

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[1]Gordon Fuller, Analytic Geometry (Cambridge: Addison-Wesley Publishing Company, Inc., 1954), p. 23.

This is assuming costs will remain the same regardless of the increased volume.

Raymond W. Andrews explains that:

> . . . the most important use of any break-even chart is that it clearly sets forth the danger area, i.e., the period in which a company operates until the break-even point is actually attained. During this period, particular attention can be focused on the various elements of cost more readily and with better results than when the break-even point has been reached or passed.[1]

It seems as though Mr. Andrews is saying costs are less important after the break-even point has been reached. This is not what he means at all, but rather, he is advocating that the break-even point should be reached as soon as possible with emphasis on decreasing cost rather than increasing the delivery rate.

Statistical Correlation Analysis

The scatter diagram method previously explained is an important technique of correlation analysis, but it lacks two chief qualities:

> (1) the coefficient of correlation estimated by visual inspection of the scattering of the points and steepness of their slope is only an approximation of the true relationships between the variables and (2) the best line fitted by freehand to the scattergram may fail, sometimes by far to give the true line of best fit, . . . and therefore estimates based on it are subject to additional error,[2]

writes B. J. Mandel of the University of Baltimore.

As was previously explained in the list of assumptions, the relationship between revenue-ton-miles and delivery expense is presumed to be linear. Linearity enables the employer of break-even analysis to

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[1]Andrews, p. 781.

[2]B. J. Mandel, Statistics for Management (Baltimore: Dangary Publishing Company, 1956), p. 254.

apply the statistical "method of least-squares." In this particular problem, the straight line that will give the best cost estimation from given observations is desired. Unless the variables have a perfectly linear relationship, no one line will intersect all points of observation. When data from Table 4 is plotted on a scatter diagram such as Figure 13, it can be seen that there is not perfect linearity. Ezekiel and Fox maintain that the "method of least-squares" will take all observations into account, and each will be given equal weight in deciding the final prediction.[1] The line constructed following the least-squares procedure will be the best possible compromise line for it will have the smallest possible departures from the actual value, Y, squared.

The reason for employing statistical correlation analysis with break-even procedures is to obtain accurate estimates. And, in this problem, cost estimates for feed distributors. As was previously indicated, cost forecasts depend on the validity of the fixed and variable cost figures. Croxton and Cowden explain the value of correlation analysis in making estimates and determining the constants in the linear equation, $Y = a+bx$, when they write:

> The scientific method . . . consists in the careful and laborious classification of facts, in the comparison of their relationship and sequences, and finally in the discovery by the aid of disciplined imagination of a brief statement or formula, which in a few words resumes a wide range of facts. Such a formula . . . is termed a scientific law. When the relationship is of a quantitative nature, the appropriate statistical tool for discovering and measuring the relationship and expressing it in a brief formula is known as correlation.[2]

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[1]Mordecai Ezekiel and Karl A. Fox, Methods of Correlation and Regression Analysis (3d ed.; New York: John Wiley and Sons, Inc., 1959), p. 61.

[2]Fredrick E. Croxton and Dudley J. Cowden, Applied General Statistics (New York: Prentice-Hall, Inc., 1939), p. 651.

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TABLE 4

LINEAR REGRESSION EQUATION APPLIED TO FEED DELIVERY COSTS AND REVENUE-TON-MILES

	(X') Revenue-Ton-Miles Per Month Coded To Thousands	(Y') Delivery Costs Per Month Coded To Hundreds	(X'Y') Product of Coded X' & Y'	(X'^2)	(x)=X'-$\bar{x}$ Difference from Mean Variable X	(y)=Y'-$\bar{y}$ Difference from Mean Variable Y	(xy) Product of Difference	(x^2) Difference Squared Variable X	(y^2) Difference Squared Variable Y	($\hat{Y}'$) Estimated Cost Per Hundred	(d) $\hat{Y}'$-Y'	(d^2)
Jan.	300	$115	34500	90000	28.17	5.25	148	794	28	116.29	1.29	1.66
Feb.	199	98	19502	39601	-72.83	-11.75	856	5304	138	92.86	- 5.14	26.42
Mar.	270	102	27540	76900	- 1.83	- 7.75	14	3	60	109.33	7.33	53.73
Apr.	346	132	45672	119796	74.17	22.25	1650	5501	495	126.96	- 5.04	25.40
May	306	116	35496	93636	34.17	6.25	214	1168	39	117.68	1.68	2.82
June	310	129	39990	96100	38.17	19.25	735	1457	371	118.61	-10.39	107.95
July	327	125	40875	106929	55.17	15.25	841	3044	233	122.25	- 2.75	7.56
Aug.	191	93	17763	36481	-80.83	-16.75	1354	6533	281	91.00	- 2.00	4.00
Sept.	211	98	20678	44521	-60.83	-11.75	715	3700	138	95.64	- 2.36	5.57
Oct.	281	105	29505	78961	9.17	- 4.75	- 43	84	23	111.88	6.88	47.33
Nov.	232	99	22968	53824	-39.83	-10.75	428	1586	116	100.51	1.51	2.28
Dec.	289	105	30345	83521	17.17	- 4.75	- 81	295	23	113.73	8.73	76.21
	Σ(X')=3262	Σ(Y')=1317	Σ(X'Y')=364,834	Σ(X'^2)=916,270			Σ(xy)=6831	Σ(x^2)=29,469	Σ(y^2)=1945	Σ($\hat{Y}'$)=1316.74	*- .26	360.93
	$\bar{x}$=271.83	$\bar{y}$=109.75										

$$b = \frac{\Sigma xy}{\Sigma x^2} = \frac{683{,}100{,}000}{29{,}469{,}000{,}000} = \$00.0232 \text{ per revenue-ton-mile}$$

$$a = \bar{y} - b\bar{x} = 10{,}975 - .0232(271{,}830) = \$4669 \text{ fixed delivery cost}$$

$$Y = 6449 + .0232X$$

$$S_y = \sqrt{\frac{\Sigma(d)^2}{n-z}} = \sqrt{\frac{360.93}{12}} = \sqrt{36.093} = 6.0077 \text{ or } \$600.77$$

$$r = \frac{\Sigma xy}{n\sqrt{\frac{x^2}{n}}\sqrt{\frac{y^2}{n}}} = \frac{683{,}100{,}000}{12\sqrt{\frac{29{,}469{,}000{,}000}{12}}\sqrt{\frac{1{,}9450{,}000}{12}}} = .9023 \qquad r^2 = .8231$$

*Due to rounding off (a) & (b) in regression equation

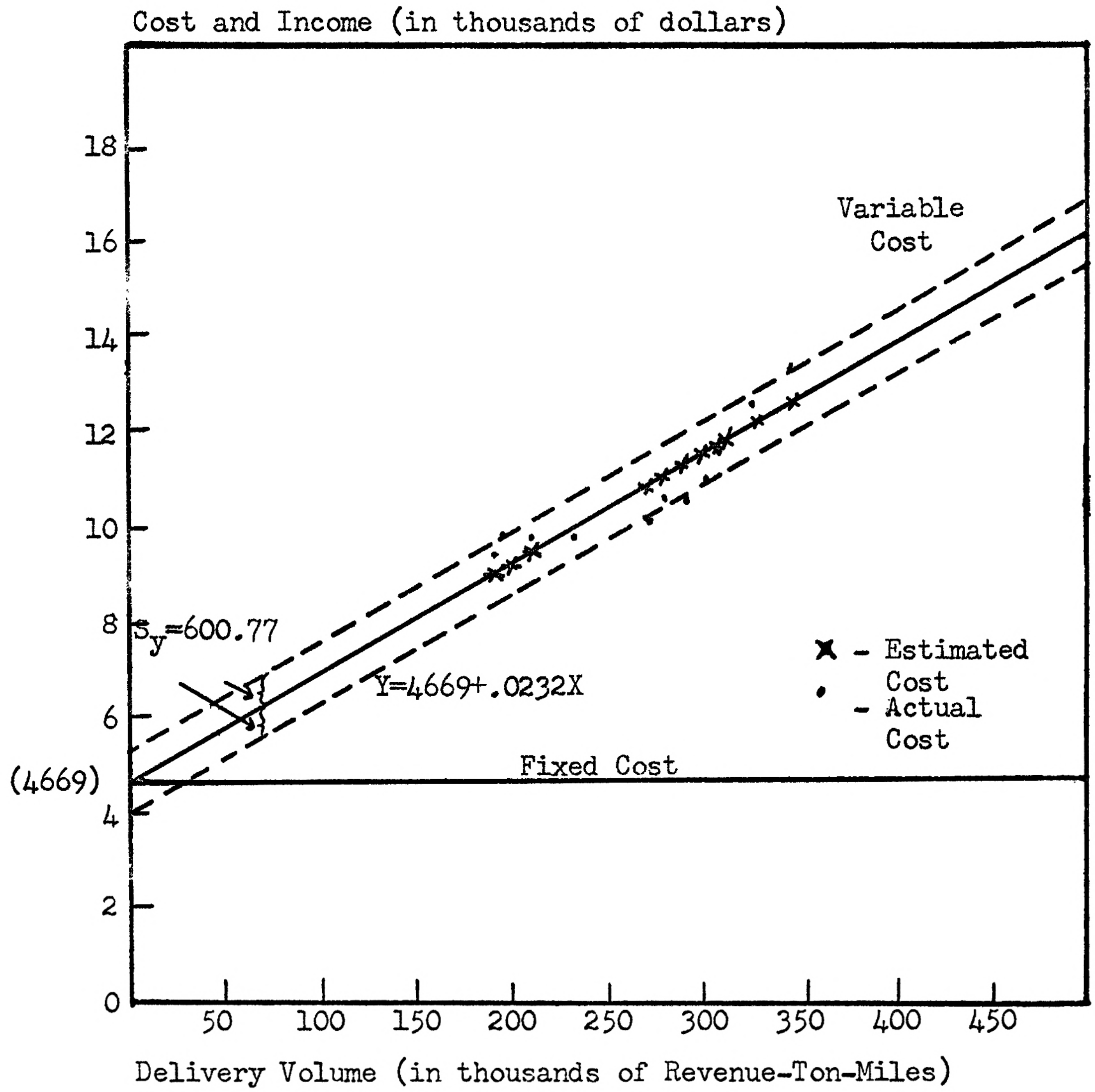

Fig. 13.--Delivery Cost estimation by method of least-squares.

The "method of least-squares" affords feed manufacturers a procedure for accurately estimating delivery expense at various volumes of delivery. The values for the linear equation in Figure 13 (Y = 4669 + .0232X) were derived from data in Table 4. The slope of the income line will depend on the rate charged for delivery. Even though the effects of rate changes and profit volumes are not presented in this paper, a valid estimation of costs provides management an accurate basis on which to set their charges.

Table 4 was constructed from hypothetical data, but the author has tried to present it in as realistic manner as possible. Monthly cost figures were based on average delivery cost that seven feed firms incurred during the month of May in 1963.[1] Demand for formula feed varies between months and as F. C. Woelffing explains, most feed is sold during the spring while demand for feed is lowest during the summer.[2] Consequently, delivery service costs more proportionally in the summer than in the spring. This is in agreement with the statement that total delivery cost bears no direct relationship to volume. If cost varied directly with volume, there would be no break-even point - the firm would always make or lose money or be breaking-even all of the time. An example of changing proportions is seen in Table 4 when the months of April and August are studied. The former is the period of greatest delivery and cost represents only 3.81 per cent of r.t.m.'s. In the month of least delivery, August, costs are 4.87 per cent of r.t.m.'s. Woelffing says this is due to the fact that during months of less demand more effort is made to obtain customers, more trucks are sent on runs at less than full capacity,

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[1] Delivery cost study conducted by Leonard W. Schruben of Kansas State University.

[2] Interview with F. C. Woelffing, President Dannen Feed Mills, June 13, 1963.

and more expense is incurred in establishing backhauls and having trucks remain idle. Reasons for the seasonal demand of feed as illustrated in Figure 14 and explained by Robert W. Schoeff are:

> (1) feed has always been manufactured to order to insure a fresh, palatable product and does not lend itself to long storage in warehouses; (2) nearly all young livestock and poultry are born or hatched in the spring; (3) farmers utilize a maximum of home grown green forage during the summer in the form of pasture; and (4) most farms are diversified crop and livestock farms, which means that livestock numbers are at their lowest during the early summer months so as not to interfere with planting, hay making and grain harvesting.[1]

By using the feed manufacturers records and varying cost in relation to seasonal demand, the cost figures in Table 4 should be reasonably accurate; although, the variations of expense and volume from month to month may be greater or less than those presented.

Table 4 was constructed so as to be as much like a normal feed delivery operation as possible. Cost and volume data are illustrated as monthly totals and are assumed to be recorded over a one year period. All tabulations are handled in a manner that would enable a feed dealer to use the record keeping system shown in Figures 6, 7, and 8 for finding all necessary totals and averages. Only twelve months were presented in this example, but it is common statistical knowledge that as the number of observations increase the accuracy of estimating by the method of least-squares will become greater. The answer to how many observations will be needed to make a legitimate estimate depends on the amount of correlation between the two variables.[2]

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[1]Schoeff, p. 19.

[2]The number of observations needed to make a certain probability statement is discussed further on page 45.

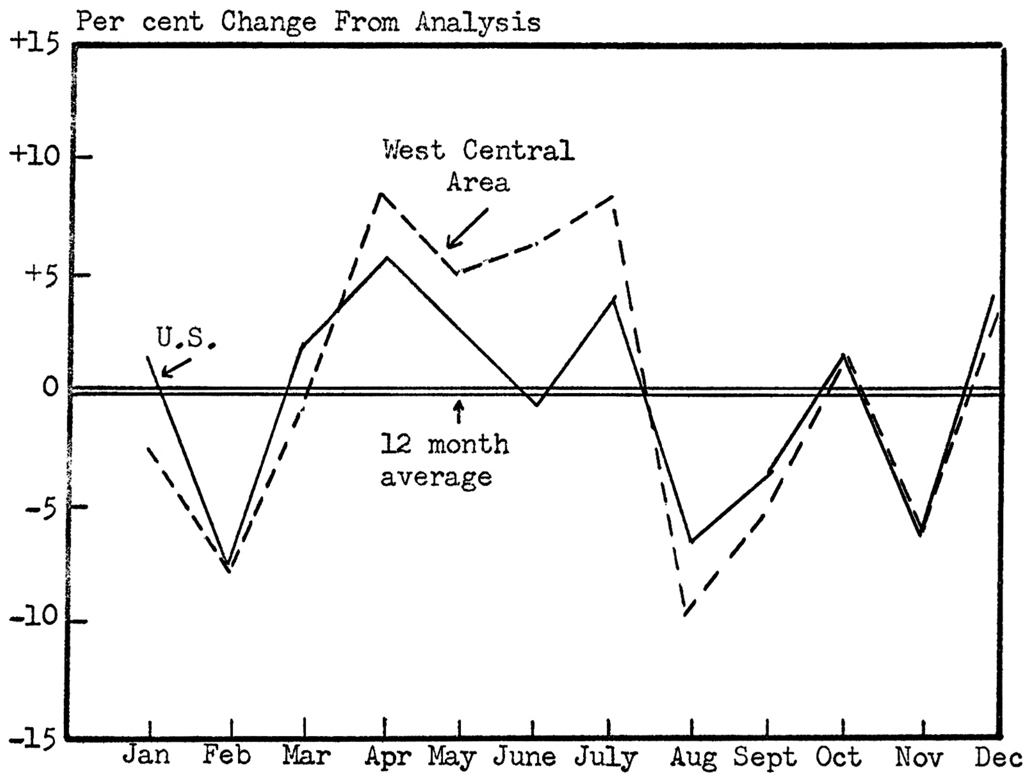

Fig. 14.--Seasonal trends in feed production[1]

[1]Schoeff, p. 19.

Monthly cost and volume figures used in forming Table 4 generally followed the assumptions that:

(1) the firm operates a ten truck fleet

(2) 250,000 r.t.m.'s were normally driven per month

(3) average monthly delivery costs were $10,000.

The appropriate number of r.t.m.'s to use in the table were compiled by following the system outlined in Table 1. Information needed for employing such a method is:

(1) tons carried per month (5,000)

(2) miles driven per month (40,000)

(3) trips made per month (400)

(4) stops made per month (900).

From these totals, it was determined that there were, on the average:

(1) 2.25 stops made per trip (2 used in example)

(2) 100 miles driven per trip

(3) 12.5 tons hauled per trip.

R.t.m.'s were found by placing these figures in Table 5.

TABLE 5

ESTIMATING REVENUE-TON-MILES PER ROUTE

Place of Departure	Destination	Tons Hauled	Miles Driven	Revenue-Ton-Miles
A	B	12.50	33.33	416.62
B	C	6.00	33.33	199.98
C	A	0.00	33.33	00.00
		Total R.t.m.'s per route		616.60
				x 400
		Total Monthly R.t.m.'s		246,640

Feed manufacturers can follow the "method of least-squares" to predict the fixed and variable cost per r.t.m. driven, the break-even point when a constant rate is charged, the amount of variation he can expect from his estimate, and the portion of delivery cost that is due to the number of r.t.m.'s driven. Croxton and Cowden explain the measurements that can be derived by correlation analysis when they write:

> (1) An estimating equation which describes the functional relationship between the two variables. As the name indicates, one object of such an equation is to make estimates of one equation from another.
>
> (2) A measure of the amount of variation of the actual values of the dependent variable from their estimated or computed values. This measure of the variation which has not been explained by the estimating equation is analogous to a standard deviation and gives an idea, in absolute terms, of the dependability of estimates. It is called the scatter, or standard error of estimate (y_s) or S_Y.
>
> (3) A measure of the degree of relationship, or correlation (r), between the variables, independent of the units or terms in which they were originally expressed. A closely related measure (r^2) will permit us to state the relative amount of variation which has been explained by the estimating equation.[1]

The procedure formula feed distributors should follow when applying the "method of least-squares" to assist in the controlling of cost should be as follows:

(1) Delivery volume will have to be recorded in a manner that allows r.t.m.'s to be computed for the various periods (in this case, one month). If the existing record keeping system does not separate fixed and variable cost, total expense figures can be used since the two components will be determined by the least-squares procedure. Expense and volume amounts should then be placed in a table such as Table 4 and coded, if necessary, into figures that can be conveniently manipulated. Other

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[1]Croxton and Cowden, p. 654.

columns in the table can be derived from the first two columns, and their equations and meanings are stated under the appropriate headings.

(2) After all columns and needed sums have been determined, the line of least-squares can be found by following the equations at the bottom of Table 4 or the system of normal equations. The former extensions are merely another way of stating the "normal equation," explains Ezekiel and Fox.[1] Calculations by one set of equations are illustrated in Table 4, and the system of "normal equations" could be applied as below:

Normal Equations:

$$(1)\ \Sigma Y^1 = na + b\, X^1$$

$$(2)\ \Sigma X^1Y^1 = a\, X^1 + b\, X^{12}$$

$$(3)\quad 131{,}700 = 12\,a + b(3{,}262{,}000)$$

$$(4)\quad 36{,}483{,}400{,}000 = 3{,}262{,}000\,a + b(916{,}270{,}000{,}000)$$

Solve equations (3) and (4) simultaneously as:

$$(5)\quad 35{,}800{,}011{,}000 = 3{,}262{,}000\,a + b(886{,}709{,}460{,}000)$$

$$(6)\quad \frac{36{,}483{,}400{,}000 = 3{,}262{,}000\,a + b(916{,}270{,}000{,}000)}{-683{,}389{,}000 = -b\ 29{,}560{,}540{,}000}$$

$$b = 683{,}389{,}000 \div 29{,}560{,}540{,}000$$

$$b = .0231$$ [2]

Use of the b value in equation (3) will determine the a quantity.

$$(7)\quad 131{,}700 = 12\,a + .0231(3{,}262{,}000)$$

$$12a = 131{,}700 - 75{,}352$$

---

[1]Ezekiel and Fox, p. 62.

[2]Difference in these values from those in Table 4 can be attributed to the rounding off procedure.

$$a = 53{,}348 \div 12$$

$$a = 4695 \quad ^{1}$$

The "method of least-squares" affords management five useful measures: (1) fixed cost (a), variable cost per unit (b), standard error of estimates (S_Y), coefficient of correlation (r), and the coefficient of determination (r^2).

Definitions of a and b have been given in previous sections and they need not be expounded on here. The amount derived for the standard error enables distributors to know how much their cost estimates, made by using the least-squares formula, are likely to deviate from the actual values. In Table 4, S_Y is computed to be $600.77 which is illustrated by dotted lines in Figure 13. This quantity is small when it is recalled that the average delivery expense per month for this hypothetical firm is $10,000. Since the variables, cost and volume, can be said to follow a normal distribution, employers of this procedure can be assured that two-thirds of their estimates will fall within the boundaries denoted by the standard error of estimate.

This measure can also be used in determining the number of observations that will be needed for stating a certain standard error. The appropriate number can be calculated by using the S_Y formula and placing in the desired standard error and then solving for n.

Croxton and Cowden give a full explanation of r and r^2 when they write:

> the coefficient of determination, r^2, is the proportion of total variance which has been explained [.8231 in this case]. The coefficient of correlation, r, is the square root of the

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[1]Difference in these values from those in Table 4 can be attributed to the rounding off procedure.

> coefficient of determination. Thus the coefficient of correlation [.9023] may be thought of as the square root of the proportion of variance that has been explained. This will, of course, always be larger than the proportion of variance which has been explained.[1]

The amount of variable delivery expense not explained by the quantity of r.t.m.'s is less than twenty per cent for the example presented in Table 4. Admitting that hypothetical quantities used in the example may have been too linear, the author still is of the opinion that as much as seventy per cent of feed delivery expense will be found to be caused by the tons hauled and the miles driven.

Adopting Break-Even Analysis to the Delivery Operation

Several systems may be used for applying cost-volume-profit analysis once the cost components have been fully identified. If management has a different method for determining cost than the ones discussed above, or if their experience enables them to pin point cost accurately, they can also adopt the following procedures and formulas for their firm's delivery department.

The purpose of this thesis is to show how delivery cost before the break-even point is reached is of chief importance and the actual break-even point serves only to show when the delivery service has surpassed the "danger area." Hanson and Brabb offer an easy method for identifying break-even points if the cost elements are known.[2] This can be applied to delivery systems, but the method loses some of the advantages of break-even analysis by determining only a point and not showing what the various costs will be prior to the break-even position. By adhering to the break-

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[1] Croxton and Cowden, p. 663.

[2] Kermit O. Hanson and George J. Brabb, Managerial Statistics (2d ed.; Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1961), p. 286.

even concept that at one location total revenue equals total cost, the volume of delivery that will be needed, assuming a constant delivery charge, to just cover distribution cost can be found by the equation: $V = a+bV$, where V is volume and a and b are rigid and variable costs. Inserting the cost figures from Table 4 and setting a delivery charge of four cents per r.t.m., the break-even volume would be computed as follows:

$$0.04V = 4669 + 0.0232V$$

$$0.04V - 0.0232V = 4669$$

$$.0168V = 4669$$

$V = 277,917$ r.t.m.'s (which agrees with Point 2 in Figure 15)

By expressing variable cost in terms of $1 of revenue ($0.0232 ÷ $0.04 = $0.58) the point can be found where the revenue received from delivery is just enough to pay for the delivery service. In the equation below, R represents revenue and zero the break-even point.

$$0 = R - 0.58R - 4669$$

$$.42\ R = 4669$$

$R = \$11,116.67$ (which also agrees with Point 2)

Break-even analysis is better utilized by the feed manufacturing firm if cost and revenue are set up in such a manner that, as Rucker explains, the feed distributor will "know both profit-wise and cost-wise 'where he is as against where he ought to be' at any given time."[1] Table 6 is set up as an example of how revenue and cost could be compared from day to day. By accurately estimating its cost for a coming month, a firm could maintain a form such as Table 6 and accurately determine whether or not the delivery department was paying for itself. During months when it

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[1]Rucker, p. 68.

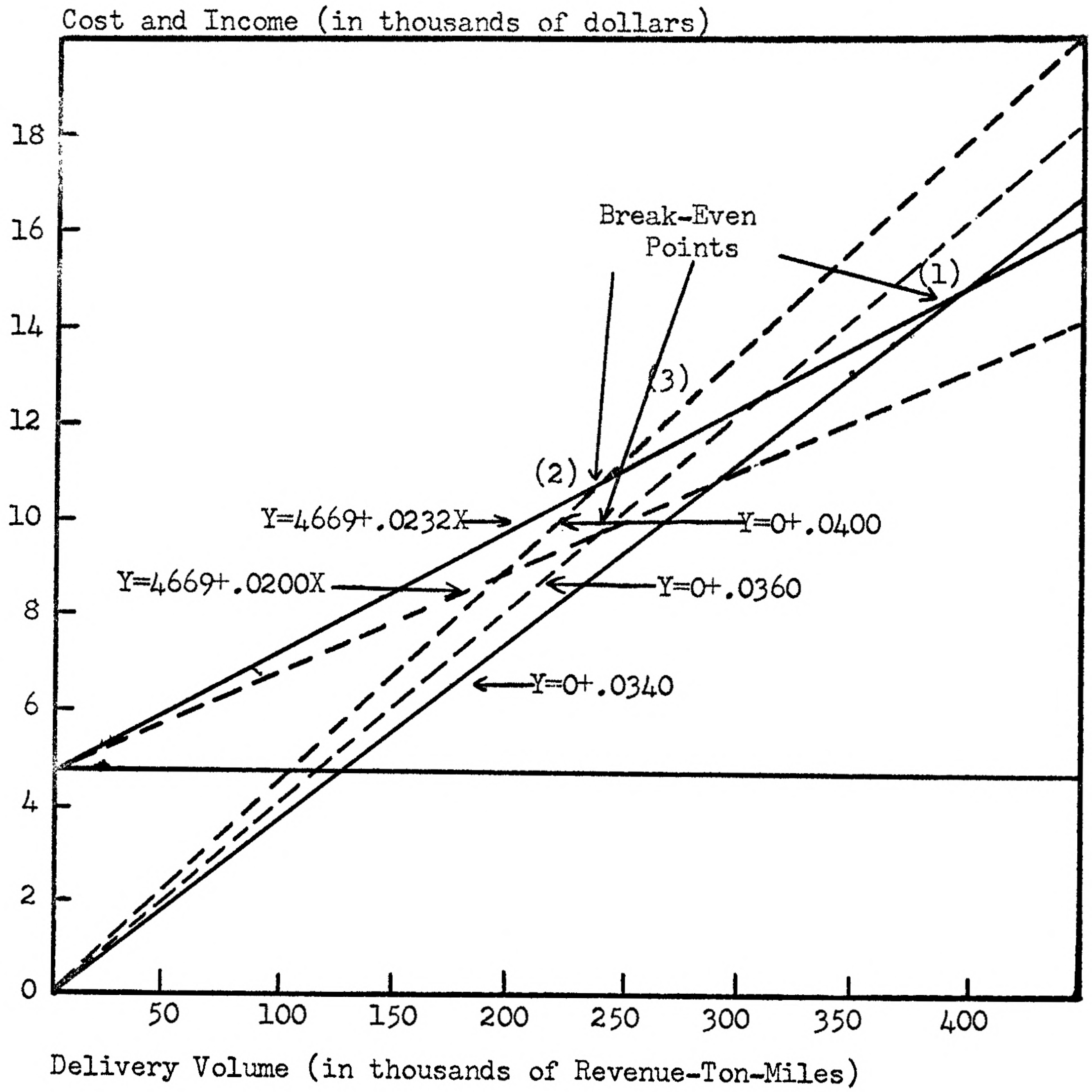

Fig. 15.--Break-even points at different cost and volume levels.

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TABLE 6

DELIVERY COSTS AT VARYING LEVELS OF VOLUME[a]

Date	(Volume) Revenue-Ton-Miles Per Day	Revenue-Ton-Miles @ 4¢ Per Unit	Accumulated Revenue	Accumulated Revenue As Per Cent of Break-Even	Delivery Costs			
					Variable	Variable Accumulated	Fixed	Total
6/ 1/63	7121	$284.84	$ 284.84	5.89%	$165.21	$ 165.21	$4669.00	$4834.21
6/ 3/63	15091	603.64	888.48	17.13%	350.11	515.32	4669.00	5184.32
6/ 4/63	12609	504.36	1392.84	25.43%	292.53	807.85	4669.00	5476.85
6/ 5/63	21023	840.92	2232.76	37.43%	487.73	1295.58	4669.00	5964.58
6/ 6/63	13021	520.84	2753.60	43.94%	302.09	1597.67	4669.00	6266.67
6/ 8/63	23097	923.88	3677.48	54.06%	535.85	2133.52	4669.00	6802.52
6/ 9/63	20066	802.64	4480.12	61.64%	465.53	2599.05	4669.00	7268.05
6/10/63	13021	520.84	5000.96	66.06%	302.09	2901.14	4669.00	7570.14
6/11/63	16025	641.00	5641.96	71.04%	371.78	3272.92	4669.00	7941.92
6/12/63	15088	603.52	6245.48	75.32%	350.04	3622.96	4669.00	8291.96
6/14/63	9211	368.44	6613.92	77.76%	213.70	3836.66	4669.00	8505.66
6/15/63	11265	450.60	7064.52	80.58%	261.35	4098.01	4669.00	8767.01
6/16/63	18299	731.96	7796.48	84.82%	424.54	4522.55	4669.00	9191.55
6/18/63	21067	842.68	8639.16	89.24%	488.75	5011.30	4669.00	9680.30
6/20/63	10151	406.04	9045.20	91.22%	235.50	5246.80	4669.00	9915.80
6/21/63	17829	713.16	9758.36	94.47%	413.63	5660.43	4669.00	10329.43
6/22/63	22090	883.60	10641.96	98.15%	512.49	6172.92	4669.00	10841.92
6/23/63	13676	547.04	11189.00	100.27%	317.28	6490.20	4669.00	11159.20
6/24/63	9421	376.84	11565.84	101.65%	218.57	6708.77	4669.00	11377.77
6/26/63	19611	784.44	12350.28	104.37%	454.98	7163.75	4669.00	11832.75

Break-Even Point $= \frac{4669}{42.00\%} =$ $11,116.62

Variable costs = 58% of delivery revenue

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TABLE 6.--Continued

Date	(Volume) Revenue-Ton-Miles Per Day	Revenue-Ton-Miles @ 4¢ Per Unit	Accumulated Revenue	Accumulated Revenue As Per Cent of Break-Even	Delivery Costs			
					Variable	Variable Accumulated	Fixed	Total
6/27/63	15023	$600.92	$12951.20	106.32%	$38.53	$7512.28	$4669.00	$12181.28
6/28/63	14956	598.24	13549.44	108.15%	36.98	7859.26	4669.00	12528.26
6/30/63	11261	450.44	13999.88	109.46%	21.26	8120.52	4669.00	12789.52
	350022		$13999.88					$12789.52

[a]Rucker, p. 75.

is apparent that revenue is too low in relation to cost, decision makers can either increase the delivery volume (by selling more feed) or reduce delivery cost in their efforts to equate cost and revenue. Management can have a clear view of the "danger area" when delivery data is recorded as in Table 6. When it is clear that the delivery service is going to more than pay for itself, the distributor is in a position to lower delivery rates and increase his net profit.

From this table executives can determine what per cent of delivery revenue will be variable cost. In this example the percentage was fifty-eight. With an automatic fifty-eight per cent of delivery revenue going to variable expenses, only a forty-two per cent operating margin is left. Rucker maintains that "the operating margin is of overwhelming significance; it is certainly one of the five most important figures in any business.[1] All rigid costs must be paid from this forty-two per cent. When management is in a position to identify total fixed expense and the operating margin, they can determine exactly how much revenue they will have to receive in order to cover fixed cost. In the above example the needed amount is $4669 ÷ 42.00% = $11,116.67.

Many business firms would set the break-even point as a goal to be achieved at the earliest possible date. But in the feed distribution business another goal can be specified. Management would want to reach the break-even point as near the end of the month as possible. If, for instance, feed had been delivered at four cents per r.t.m. based on a variable cost figure of 2.34 cents per r.t.m., the firm might set a goal for holding variable cost to two cents whereby they could drop their delivery charge

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[1] _Ibid._, p. 80.

to 3.60 cents per r.t.m. and still break even at the same volume (277,917 r.t.m.'s). In this manner emphasis has been placed on cost control which will indirectly mean more company profits.

Table 7 illustrates another method in which feed dealers might utilize cost-volume-profit analysis. In this example, the effects of varying delivery charge, volume, and variable costs can be visualized. The change in present policy that would yield the greatest increase in returns would be to raise the delivery charge ten per cent. This would give a 38.33 per cent increase in net profit whereas the same ten per cent decrease in variable cost would raise net profit only 23.66 per cent. How many feed distributors feel they can afford to raise their delivery rates? Unless volume can be increased by reducing excess capacity, which is another way of lowering cost, reduced variable expense offers a better alternative than volume changes. It is logical to assume that profit oriented feed firms will always be trying to sell as much feed as possible. However, the additional 13.33 per cent to profit that a ten per cent volume increase affords, may persuade management to increase their sales efforts. Table 7 shows the effects various policy changes will have upon a firm's break-even position, and it is this author's contention that the area of variable expense represents the main source for improvement.

Although in the interest of time and space, break-even analysis has not been applied to individual truck operations; this should not present feed distributors any additional problems. Linear regression analysis could be applied to cost data derived from one specific truck and determine its fixed and variable costs. The firm could then determine how much feed the vehicle would have to carry to pay for itself. If this were done for several trucks, the cost equations could be studied and

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TABLE 7

BREAK-EVEN ANALYSIS SHOWING CHANGES IN DELIVERY RATE, VOLUME, AND VARIABLE EXPENSES[a]

	Actual (thousands of dollars)	Rate		Variable Expense		Volume		Rate -10%, Variable Expense -10%, Volume +5%	Rate +10%, Variable Expense +10%, Volume -5%
		+10%	-10%	+10%	-10%	+10%	-10%		
		A	B	C	D	E	F	G	H
Revenue: (thousands of revenue-ton-miles)									
280 @ 4¢ per r.t.m.	$11.20								
280 @ 4.4¢ per r.t.m.		$12.32							
280 @ 3.6¢ per r.t.m.			$ 10.08						
280 @ 4¢ per r.t.m.				$ 11.20					
280 @ 4¢ per r.t.m.					$11.20				
308 @ 4¢ per r.t.m.						$12.32			
252 @ 4¢ per r.t.m.							$ 10.08		
294 @ 3.6¢ per r.t.m.								$ 10.58	
266 @ 4.4¢ per r.t.m.									$11.70
Less Variable Expense: (thousands of r.t.m.'s)									
280 @ 2.32¢ per r.t.m.	6.50								
280 @ 2.32¢ per r.t.m.		6.50							
280 @ 2.32¢ per r.t.m.			6.50						
280 @ 2.55¢ per r.t.m.				7.14					
280 @ 2.09¢ per r.t.m.					5.82				
308 @ 2.32¢ per r.t.m.						7.15			
252 @ 2.32¢ per r.t.m.							5.85		
294 @ 2.09¢ per r.t.m.								6.14	
266 @ 2.55¢ per r.t.m.									6.78

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TABLE 7.--Continued

	Actual (thousands of dollars)	Rate		Variable Expense		Volume		Rate -10%, Variable Expense -10%, Volume +5%	Rate +10%, Variable Expense +10%, Volume -5%
		+10%	-10%	+10%	-10%	+10%	-10%		
		A	B	C	D	E	F	G	H
Marginal Income	$ 4.70	$ 5.82	$ 3.58	$ 4.06	$ 5.38	$ 5.17	$ 4.23	$ 4.44	$ 4.92
Fixed Expenses	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67
Net Profit (Loss)	0.03	1.15	(1.09)	(0.61)	0.71	0.50	(0.44)	(0.23)	0.25
Managerial Information:									
Net profit ratio[1] (in %)	.27	9.33	(1.08)	(5.45)	6.34	4.06	(4.36)	(2.17)	2.13
Profit-Volume ratio[2] (in %)	41.96	47.24	35.51	36.25	48.03	41.96	41.96	41.96	42.05
Break-Even revenue[3]	11.13[b]	12.32	13.15	12.88	9.72	11.13	11.13	11.13	11.10
Per Cent changes in net profit[4]	00.00	38.33	(36.33)	(20.33)	23.66	13.33	(14.66)	(7.66)	8.33

(1) Net Profit divided by revenue

(2) Marginal income divided by revenue

(3) Fixed expense divided by profit volume ratio

(4) Actual equals 100%

[a]Woelfel, p. 32.

[b]Different from Figure 15 because 280 r.t.m.'s were used instead of 277.

executives could identify the less efficient trucks or operators, or both. Cost-volume-profit analysis could be broken down even farther to aid the firm in deciding how much feed a truck must haul and the rate it would need to charge in order to break even on specific routes. Many feed firms set boundaries around their plant and quote prices for each area as to the minimum number of tons they will deliver to each area. For instance the firm might list prices as:

50 Mile Empty Return - 5 Ton Minimum Load - $2.33 per ton

100 Mile Empty Return - 7.5 Ton Minimum Load - $5.74 per ton

150 Mile Empty Return - 10 Ton Minimum Load - $8.53 per ton

200 Mile Empty Return - 10 Ton Minimum Load - $11.94 per ton

Table 8 is used to illustrate the manner by which break-even rates can be derived. In this case the author has chosen to use medians of the different areas, i.e., 25 for 0 - 50. If the fartherest miles for each strata had been employed in determining the rates, only the customers at the outer limits would receive feed at the true expense. By using medians, the final charge will be one that overcharges about one-half the customers in the area and undercharges the remaining one-half. This method takes into account the expense for operating an empty truck. The need for accurate routing and frequent backhauls is clearly shown. Table 8 is based on the assumption that a full load is carried to the destination and the truck is driven empty on the return trip. Individual firms will be responsible for establishing their own delivery areas and minimum loads. The tonnage figures in Table 8 were based on the assumption that the firm was operating ten-ton trucks. Mileage intervals were set arbitrarily. Distributors would need to make an intensive study of their customer's locations to establish delivery areas in accordance with

TABLE 8

METHOD FOR DETERMINING DELIVERY CHARGE IN VARIOUS DELIVERY AREAS

Mile Intervals	(A) Minimum Ton Hauled	(B) Empty Miles	(C) Revenue-Ton-Miles (A) x (B)	(D) Total Cost Per Empty Mile At $0.25 Per Unit	(E) Total Cost Per Revenue-Ton-Mile At $0.0432 Per Unit	(F) Total Cost For Round Trip (D) + (E)	(G) Break-Even Delivery Charge Per Ton (F) ÷ (A)
0 - 50	5	25	125	$ 6.25	$ 5.40	$ 11.65	$ 2.33
51 - 100	7.5	75	562.5	18.75	24.30	43.05	5.74
101 - 150	10	125	1250	31.25	54.00	85.25	8.53
151 - 200	10	175	1750	43.75	75.60	119.35	11.94

cost data. In actuality, dealers would probably not be able to set constant intervals, but would rather establish their territories in accordance with road conditions, state lines, volume sold, etc. It would be absurd to think a feed distributor wouldn't reduce the delivery rate to a high volume customer just because he lived a few miles into the next area. But this type of cost analysis does give management accurate data by which to conduct their bargaining procedures. In Table 8, for instance, if the feed firm could enter into a contract with a packing plant, one hundred miles away, to provide meat scraps for each feed delivery, the rate could be reduced to $3.24 per ton ($48.60 ÷ 15 tons).

Summary

It should be understood that break-even analysis is not a perfect and "all-answering" managerial tool. Even though the author explained the manner in which adjustments must be made for feed distributors to utilize break-even analysis in accordance with the basic assumptions, disadvantages may still be encountered when it is applied to the particular firm. Major limitations seem to be due to the presumptions of linear relationships and constant truck mix. Richard W. Conway, an ardent opponent of this simplified procedure, explains that:

> The widespread adoption of simple break-even analysis by business executives . . . is somewhat surprising and comes in the face of potent and grievious shortcomings which should on the surface severly limit the usefulness of this device. [He adds that] the technique offers a static analysis to a dynamic problem.[1]

Conway's main argument is based on his feeling that cost-volume-profit

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[1]Richard W. Conway, "Breaking Out of the Limitations of Break-Even Analysis," National Association of Cost Accountants Bulletin, XXXVIII, No. 10 (June, 1957), p. 1265.

relationships are more fully identified when computers are employed. As to this date, little information has been published concerning the manner in which this might be done. It is clear that curvilinear cost and revenue functions would be more accurate, but would the added cost make the entire break-even procedure unprofitable? An Operations Research specialist, Robert S. Weinberg, pointed out in a progress report the manner in which multiple factor break-even analysis might be carried out.[1] The method presented utilized mathematics which are probably beyond the scope of the normal feed distributor. Since Weinberg has applied his procedure to less than twenty firms, two from which he could gain no conclusive decisions, it would be inappropriate to prescribe it for feed distributor's use at the present time.

Too much reliance on break-even charts can prove to be a detriment to management. It is generally concluded that break-even figures should be used for approximation rather than setting exact cost and volume quantities at various levels of delivery. But break-even methods which follow algebraic rather than geometric procedures tend to have more accuracy. Yacobian maintains that inaccuracies will become more acute as the break-even point is neared.[2]

The break-even chart can also be over-used. Firms that overstep the boundaries of cost-volume-profit analysis may find that it is actually a hinderance to their decision making process. Assumptions must be followed and the precision of this method is seriously lessened when they are

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[1]Robert S. Weinberg, _et al._, _Mathematical Models and Methods In Marketing_ (Homewood, Ill.: Richard D. Irwin, Inc., 1961), p. 66.

[2]Yacobian, p. 28.

not. Other records and "common sense" must also be considered when cost and revenue predictions are made.

Unless decision makers are experienced in formulating break-even tables and charts, the instrument may prove to be undynamic. When changes are made and assumptions are altered, charts and tables will have to be constructed for each variation. By having a group of charts, management can foresee the effects of policy changes; thus, making break-even analysis a semidynamic procedure.

If the present record keeping system is inadequate for adopting break-even analysis, the cost for implementing a new one may also be a major disadvantage. This may lead some firms to the conclusion that this method of analysis is not worthwhile or that their personal estimates will suffice for the needed data. To do this, and then to rely heavily upon the findings will probably be worse than not implementing cost-volume-profit analysis at all.

Firms that have employed this type of analysis within its limitations have found it to be a very useful tool for making sound judgments. Even though Conway realizes serious limitations are inherent in simple break-even analysis, he does concede that:

> Nevertheless, the practice has flourished, continually acquiring new adherents and new uses. One can conclude that an unsuspected stability exists which makes practical the use of a static tool, that empirical cost and revenue functions of acceptable quality are forthcoming from existing reporting and record keeping procedures at a reasonable cost . . . and that, in short, the break-even chart is an effective tool for gross profit planning in spite of recognized limitations.[1]

The main advantage of break-even analysis in delivery operations is that it requires a full knowledge of cost. Hence, delivery supervisors

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[1]Conway, p. 1265.

must become cost conscious if they are to adopt this method for analyzing costs. When costs are compared with revenue in the manner that break-even analysis requires, management can see that costs vary in a disproportional relationship to revenue.

Yacobian does not think break-even analysis is as undynamic as some other cost accountants indicate. He maintains that if the break-even chart is constructed from historical data and prepared budgets and policies are projected into it, then break-even analysis is a dynamic tool from which executives "can look forward, to plan, to control, and coordinate all activities of the business into the most profitable or potentially profitable course and keep it there."[1]

It would be possible to compile a comprehensive list of opinions, both pro and con, concerning the usefulness of break-even analysis. But this would serve to only add more confusion. Individual firms will have to adopt the method to their particular case and find out for themselves if the break-even assumptions are too limiting. In conclusion, it is the firm belief of this student that break-even analysis can prove to be an important asset in feed delivery operations.

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[1]Yacobian, p. 27.

CHAPTER III

TRUCK REPLACEMENT POLICY

Introduction

Feed manufacturers are afforded an important cost control system when they establish a sound truck replacement policy. As the life of a motor carrier increases, its maintenance and operating costs rise accordingly. By knowing when these expenses have increased to such a level that it would be more economical to replace a truck rather than maintain it, management is able to minimize repair cost due to deterioration and to keep its capital outlay for owning or leasing trucks as small as possible. In other words, optimal re-equipment programs furnish feed distributors a method for operating the most efficient delivery trucks at the least possible cost.

Before feed distributors can be persuaded to spend the time and money necessary for formulating an economically sound replacement program, they must be aware of the advantages it will offer them. Cost comparisons will be illustrated in the section on methodology, but there still remains many indirect reasons for adopting a truck rotation program.

Feed delivery firms may find that avoidable expenses incurred by a poor replacement policy tend to become larger each year. They will find that revenue which previously came into the firm as profits must later be used for truck maintenance and repair. Later, additional funds will be required for maintaining the present carriers. Officials will find they are not able to maintain an adequate monetary reserve; and when the time comes for the truck to be traded, there will be no reserve funds available. Management will then have to borrow money for a new replacement or use some of the profits made by another department; either choice of which could have been avoided by an efficient re-equipment system.

Although the above example may have been carried to the extreme, the Replacement Manual, edited by the Machinery and Allied Products Institute (MAPI), indicates the so called "sound judgment" and "rule-of-thumb" methods used by many managers may be just as absurd.[1] After interviewing the officials of three public utilities in a large city, the Institute found that even though all three had similar vehicles, one replaced every year, another every three or four years, and the latter every five or six years.[2]

There are two "rule-of-thumb" approaches followed by many executives when they set up their re-equipment pattern. First is the rate of return concept. Management feels there is a specific annual cost savings, expressed as a per cent of initial cost, which the new asset should afford the firm. If a firm's officials decide they must receive a savings of twenty-five per cent of the original cost for a truck which retails for $8000, it would mean that before the vehicle was purchased the executives would have to be sure it would save the company $2000 annually. The second type of re-equipment measure frequently used is the short-payoff requirement. In this case emphasis is placed on the number of years that will be required for the carrier to pay for itself through annual savings. For the same $8000, a four year payoff period would require that the

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[1]MAPI Replacement Manual (Washington: Machinery and Allied Products Institute, 1950), p. 2.

[2]Ibid.

truck reduce delivery expenses $2000 annually. Truck data received from seven feed firms indicated they expected their carriers to pay for themselves in approximately four years. It is found, however, that all industries do not require the same service periods. In the Wichita, Kansas, vicinity, milk haulers operate their trucks only two years.[1]

This paper does not show whether or not these stated periods are the most economical, but it can be pointed out how costly incorrectly derived periods may be. The Replacement Manual indicates executives generally do not know why they set certain payoff periods and rate of return percentages.[2] The reason most commonly stated is that the specification is made so the replacement pattern will provide a certain amount of safety. However, this safety margin may prove to be non-existent when re-equipment costs are compared with the expenditures the most economical displacement procedure would require.

What extra expense would a company incur if trucks were selling for $8000 and it required a two year payoff period when actually it should have allowed four years? Replacement should occur when annual cost savings are $2000, but the firm refuses to trade until $4000 can be saved each year. Assuming a carrier had just reached the age at which it should be displaced, or a new vehicle would provide an annual cost savings of $2000, it can be shown the firm will have to maintain the truck much longer than necessary and by doing so they will experience additional costs. Displacement will not take place until a $4000 savings level is reached. If at this time company officials find the average cost savings

[1]Interview with Paul L. Kelley, Prof. Agricultural Economics, Kansas State University, June 21, 1963.

[2]MAPI Replacement Manual, p. 3.

offered by a new carrier increases $400 per year, the additional cost for prolonging replacement can be determined as below:

Year	Unrealized Annual Cost Savings	Amount at Which Replacement is Justified	Accumulated Avoidable Cost
4	2000(level at which replacement should	2000	0000
5	2400 have occurred)	2000	400
6	2800	2000	1200
7	3200	2000	2400
8	3600	2000	4000
9	4000(when replacement was made)	2000	4000

Procedure described by MAPI Replacement Manual, p. 5.

At the end of the four years, savings would have been at the appropriate replacement level. It is determined it will take five additional years of maintaining the truck if the desired savings are to be realized (2000 ÷ 400). The $4000 added cost is quite a sum when the truck's initial cost is only $8000. These costs could have been avoided if a four year payoff program would have been incorporated into the company policy. Feed distributors would undoubtedly realize the truck would not be economical for nine years, but if they waited until the seventh year, unnecessary cost would still have amounted to $2400.

An overcautious firm can also lose money. By reversing the conditions assumed above, management would require a two year plan where they formerly insisted on four years. Officials should have waited until the level of $4000 was capable of being saved, but instead, they traded for the new truck when it saved their company only $2000 annually. Avoidable costs are computed in the following manner:

Year	Savings Needed For Replacement	Realized Cost Savings	Accumulated Avoidable Cost
2	4000	2000(when replacement was made)	0000*
3	4000	2400	1600
4	4000	2800	2800
5	4000	3200	3600
6	4000	3600	4000
7	4000(level at which replacement should have occurred)	4000	4000

*Avoidable costs are not computed until after replacement is made.

Procedure explained by MAPI Replacement Manual, p. 5.

The truck was traded five years too soon and the early trading as shown in the above example cost the firm $4000.

The normal feed delivery truck should be one that is reliable, operates economically, preserves the quality of the feed and is adapted to the overall feed manufacturing operation. Profitable markets may be eliminated if management is reluctant in sending their trucks on long hauls. Even though plant officials may be doing an excellent job of controlling feed production costs, if their delivery equipment has deteriorated to such an extent that it can serve only the present customers, then delivery is actually limiting the company's sales potential. This factor will become even more important with the nation's increased livestock production. By being able to reach distant markets, feed firms can also discourage the construction of new feed plants that present increased competition.

With more emphasis on delivering feed in bulk form, there also is the risk of having added feed spoilage. In areas where feed sales competition is intense, customer satisfaction cannot be sacrificed. But as F. C. Woelffing points out, this factor is not as important in feed sales as it is in other industries where the product is also delivered.[1] Feeders trade where they can obtain the least-cost product.

Delivery equipment may sit idle during some production periods while at other times it may be insufficient to meet customer demand. This is clearly a problem for individual companies to solve but an optimal truck rotation program can alleviate it to some extent by assuring company officials that only the most efficient trucks are being purchased and maintained.

Leasing programs, new and used truck prices, operating costs, and vehicle capacity are all items that influence feed distributor's replacement policies. Truck manufacturing companies have found they can obtain a substantial profit by leasing vehicles to delivery firms. Leasing contracts are made on either a mileage or time basis. Firms that choose the time contract usually do so with the feeling they will utilize the carriers to the fullest extent. A mileage basis is selected by firms that contemplate their trucks will be idle part of the time due to adverse economic conditions. Leasing agreements call for a set truck rotation program which would seem to place the burden of replacement determination in the hands of the truck dealer. The real problem for feed company officials is to determine their own least-cost replacement plan and then compare it with the leasing contracts available. It may be that the individ-

[1] Woelffing interview.

ual firm can actually buy and sell trucks with less total expense than it could obtain trucks through a rental contract.

The second hand truck offers management another alternative for reducing delivery expense. Some feed distributors maintain only second hand trucks are profitable trucks. Again, this has to be solved for each particular case. The purchaser of second hand trucks may find that even though he is eliminating the high initial new truck cost, maintenance and operating expenses are at such a level the second hand trucks are uneconomical.

As can be seen, there are many problems that arise in the delivery section of feed producing firms. Many of which could be answered by following the optimizing procedures prescribed in replacement theory. The remaining part of this chapter will be concerned with explaining replacement theory and the various ways it can be adopted for reducing total delivery costs. Explanation will follow a type of combined Economic and Operations Research approach. Economists tend to present a theoretical analysis, while Operations Research specialists' give numerous examples - assuming the theory is already known. The author of this thesis has placed emphasis on formulating a procedure whereby the individual feed distributor can incorporate replacement theory as an additional method for minimizing delivery costs.

Definitions and Assumptions

Two General Postulates

Before management can derive their most economical re-equipment program, they must have full knowledge of the assumptions on which replacement theory is based. Purchase price, deterioration or depreciation, obsolescence, and salvage value are the main variables to be considered when constructing a replacement formula. These will be defined and discussed at length in the latter part of this section. The values that will be given these items will depend upon particular situations, but there are two assumptions that underlie all capital asset replacement equations, which are stated by Terborgh as:

> (1) Future challengers will have the same adverse minimum as the present one.
>
> (2) The present challenger will accumulate operating inferiority at a constant rate over its service life.[1]

The first assumption pertains to items presently owned. It is based on the principle that future costs for equipment on hand need to be estimated for only one additional year. When the defender's adverse minimum, or the amount the present item falls short of performing as efficiently as its best replacement plus the capital expense it incurs for the given year, is computed for the next year's operation, it must be lower than that offered by the challenger, or it will have to be traded.

Since the assumption maintains the adverse minimums of future challengers will be the same as the current best alternative, capital items on hand have to be compared only with the available challenger. Terborgh agrees there are periods when future equipment offers lower adverse minimums, but he also argues there are times when the opposite change will occur.[2] It seems logical that assumption of equal adverse minimums is the best one that could be made under the prevailing conditions.

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[1]George Willard Terborgh, Dynamic Equipment Policy (New York: McGraw-Hill Book Company, Inc., 1949), pp. 64-65.

[2]Ibid., p. 64.

Francois J. Olmer, of the Illinois Institute of Technology, maintains that in a market characterized by free competition the forces of supply and demand will force the adverse minimums of both the defender and challenger to be equal.[1] By adhering to this concept, Olmer was able to construct Figure 16. The rise and fall of salvage values will equate minimum average cost (A_0 and A_1), and firms will be indifferent as to the equipment they purchase. It should be understood that the purchase price of a used item was previously its salvage value. If there is relatively little demand for a used truck, its salvage value will reach such a low level that feed distributors will realize the least adverse minimum is offered by the used vehicle. This phenomenon will also proceed in the opposite direction if salvage values are too high.

It cannot be supposed, however, that all feed manufacturers have equal information. If firms that follow the practice of buying only used trucks would formulate their own least-cost displacement pattern, they would probably find that in many cases they should purchase new trucks. This gives further emphasis to the fact that feed dealers should know when to replace their motor carriers.

The second general postulate maintains the best alternative available will accumulate deterioration and obsolescence (operating inferiority) in a linear fashion. Feed distributors can assume the best new truck on the market will become inferior to newer models at a constant rate. Delivery trucks become obsolete when major technological advances are made and these do not seem to follow any set pattern. But as Terborgh writes, "when we are dealing with occurrences spaced in random

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[1]Francois J. Olmer, "A New Approach to the Determination of Replacement Costs," Management Science, VI, No. 1 (October, 1959), p. 115.

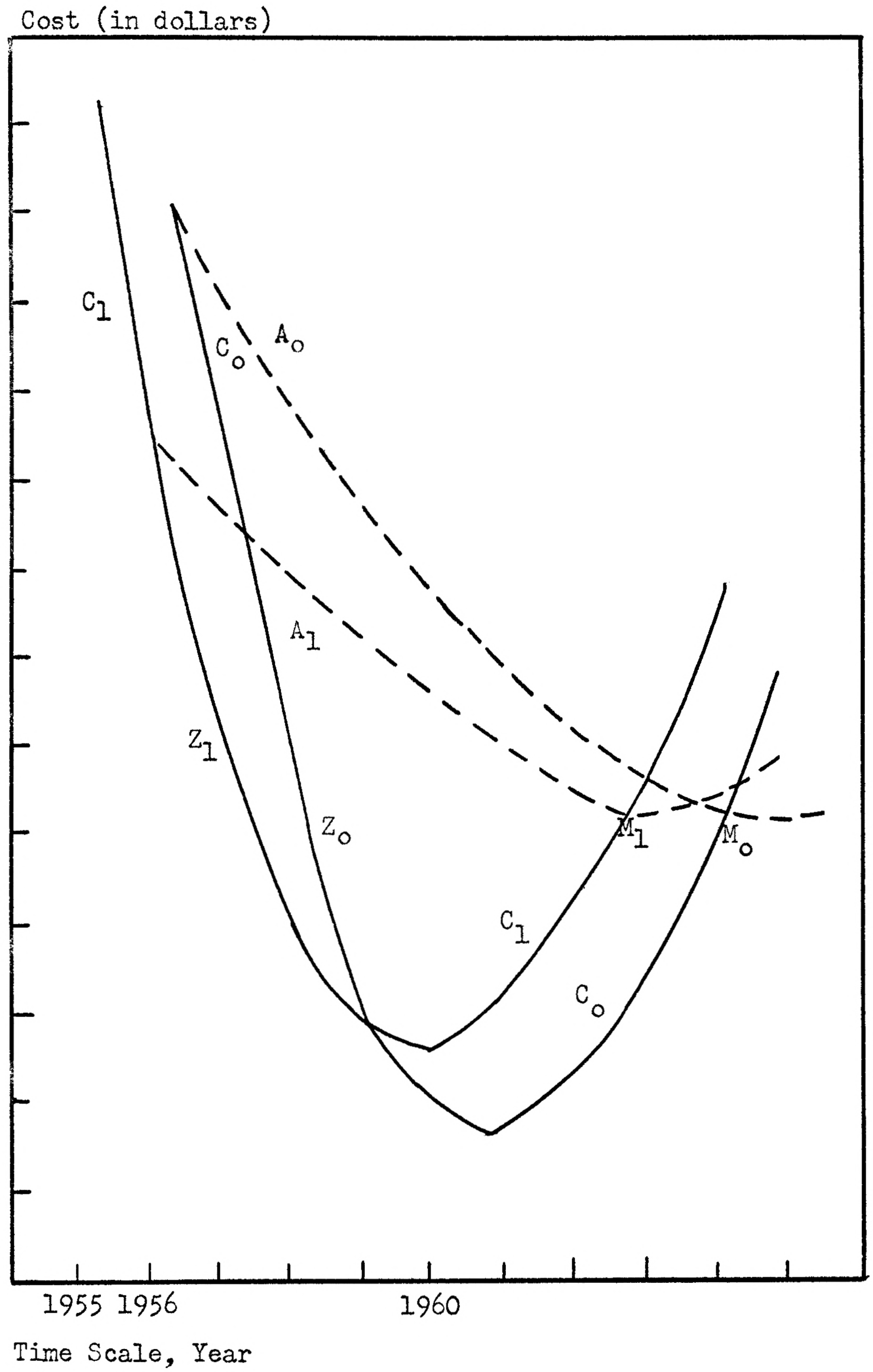

Fig. 16.--Average costs for new and used replicas.[1]

[1]Olmer, p. 113.

fashion over time, the best standard assumption we can make is that they will occur at a uniform rate."[1]

Deterioration, which makes up the other portion of operating inferiority, is also assumed to follow a rather linear pattern. Depreciation will be the major expense factor in the machine's early life, but as this cost decreases other expenses will increase. Expenditures due to maintenance, down-time, and overhauls increase as the truck becomes older. According to feed delivery costs presented by R. R. McEllhiney, production manager, feed division, Albers Milling Company, in Feedstuffs, fixed expenses for sacked delivery and bulk delivery trucks amount to thirty-six and forty-one cents per ton respectively.[2] Cost figures for milk delivery operations compiled by Cook, Halvorson, and Robinson, of the University of Wisconsin, showed depreciation amounted to fifty-five per cent of total fixed truck expense.[3] Since it was previously pointed out that milk trucks are traded off nearly twice as often as feed trucks, the author has chosen to assume that thirty per cent of fixed feed delivery expenses are due to depreciation. Thirty per cent of McEllhiney's data would indicate that depreciation costs per ton would be 10.8 and 12.3 cents for the two types of carriers. McEllhiney showed in this same article that maintenance cost for sacked and bulk delivery trucks was ten and twenty cents per ton. Depreciation plus maintenance expense per ton hauled would then be 20.8 cents for delivering feed in sacks and

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[1]Terborgh, p. 68.

[2]Roger Berglund, "Production, Delivery Cost Data Told," Feedstuffs, XXXV, No. 8 (February 23, 1963), p. 91.

[3]Hugh L. Cook, Harlow W. Halvorson, and R. Wayne Robinson, Costs and Efficiency of Wholesale Milk Distribution in Milwaukee (Research Bulletin 196) Madison, Wis.: University of Wisconsin, May, 1956, p. 24.

32.3 cents for distributing bulk feed. The linear rate that deterioration would increase in relation to time could not be determined because no figures were given as to the annual fixed delivery cost. But it was pointed out that repair cost per mile would increase at the rate of four cents per unit.

It appears the second postulate will apply to feed delivery operations in the same manner as it does to other industries that face replacement problems. While the estimation of obsolescence will be largely a judgment decision, deterioration rates are supported by the firm's internal records.

Churchman, Ackoff, and Arnoff point out in their Operations Research text that firms cannot oversimplify replacement by making too broad assumptions.[1] Cost estimates have to be made for the firm's individual situation. But since these authors fail to offer a better method for predicting costs, it is felt Terborgh's assumptions of linearity will afford accurate cost estimates of feed distribution.

Replacement

At some time during the life of an owned asset, its annual average cost, consisting of capital and maintenance expenses, will rise to such an extent that a new piece of equipment should be purchased. Determining when the defender should give way to the challenger is the problem facing management when replacement programs are considered.

Replacement theory pertains to two classes of equipment - that which deteriorates over time and that which fails completely. Machines

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[1]C. West Churchman, Russell L. Ackoff, and E. Leonard Arnoff, Introduction to Operations Research (New York: John Wiley and Sons, Inc., 1957), p. 489.

and vehicles would be placed in the first category while radio tubes and light bulbs would be examples of items falling under the second heading. Replacement policies for items that fail completely are determined by methods of probability analysis. Determination of the optimum replacement program for deteriorating capital equipment is accomplished by comparing annual and future annual average cost for various alternatives. Capital items will reach some period at which their annual average costs are at a minimum; this is the time replacement should take place. This indicates that the validity of a formulated replacement pattern depends on the accuracy of predicted costs and economic changes.

Phillip Scheuble explains in the Harvard Business Review that replacement policies are concerned with many estimates of the future as to:

> (1) Whether the necessary volume will be maintained to realize the operating cost advantages of the new equipment.
> (2) Whether there are possible alternate uses of that equipment.
> (3) Whether overhaul of present equipment would be sufficient, and for how long.
> (4) Whether more advantageous equipment will appear on the horizon in the near future.[1]

The Machinery and Allied Products Institute's, Company Procedural Manual on Equipment Analysis, points out that to have an effective replacement policy:

> makes it necessary, first of all, to know what cost-saving or profit-making opportunities are available. It means secondly that it is important to know also what it is costing not to take advantage of these opportunities. For if acquisition or

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[1]Phillip A. Scheuble, Jr., "How to Figure Equipment Replacement," Harvard Business Review, XXXIII, No. 5 (September-October, 1955), p. 81.

> replacement takes place either too early or too late, avoidable costs are incurred and profits otherwise available are not realized.[1]

Although it is common knowledge that trucks deteriorate over time, there are few feed distributors that know exactly how much. Figure 17, which was taken from a chart prepared by George Terborgh for his text Dynamic Equipment Policy, illustrates the various rates at which trucks, truck-tractors, and trailers degenerate over time. His figures were taken from national averages which covered many different industries, but the deterioration of feed delivery equipment should not be much different. The charts for the various classes of equipment are not studies of the same group of capital assets over fifteen years, but rather, they represent equipment of different ages. For instance, the first year data shows the average number of miles driven by the current model trucks and trailers whereas the second year figures pertain to average mileage logged by carriers and trailers one year older. From this it should be understood that some of the decline in productivity may be due to obsolescence as well as deterioration.

To determine the percentage decline in utilization for each type of equipment, Table 9 was constructed from the three charts in Figure 17.

The table indicates that truck's and truck-tractor's usefulness degenerates about ten per cent each year. However, national figures for trailers are in direct conflict with the actual feed delivery situation. The table shows that a trailer's use declines approximately fifteen per cent annually. Since most feed firms operate their trailers two to three times as long as they do their truck-tractors, it is logical to assume

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[1]Company Procedural Manual on Equipment Analysis (Chicago: William Kelly and Company, 1951), p. 8.

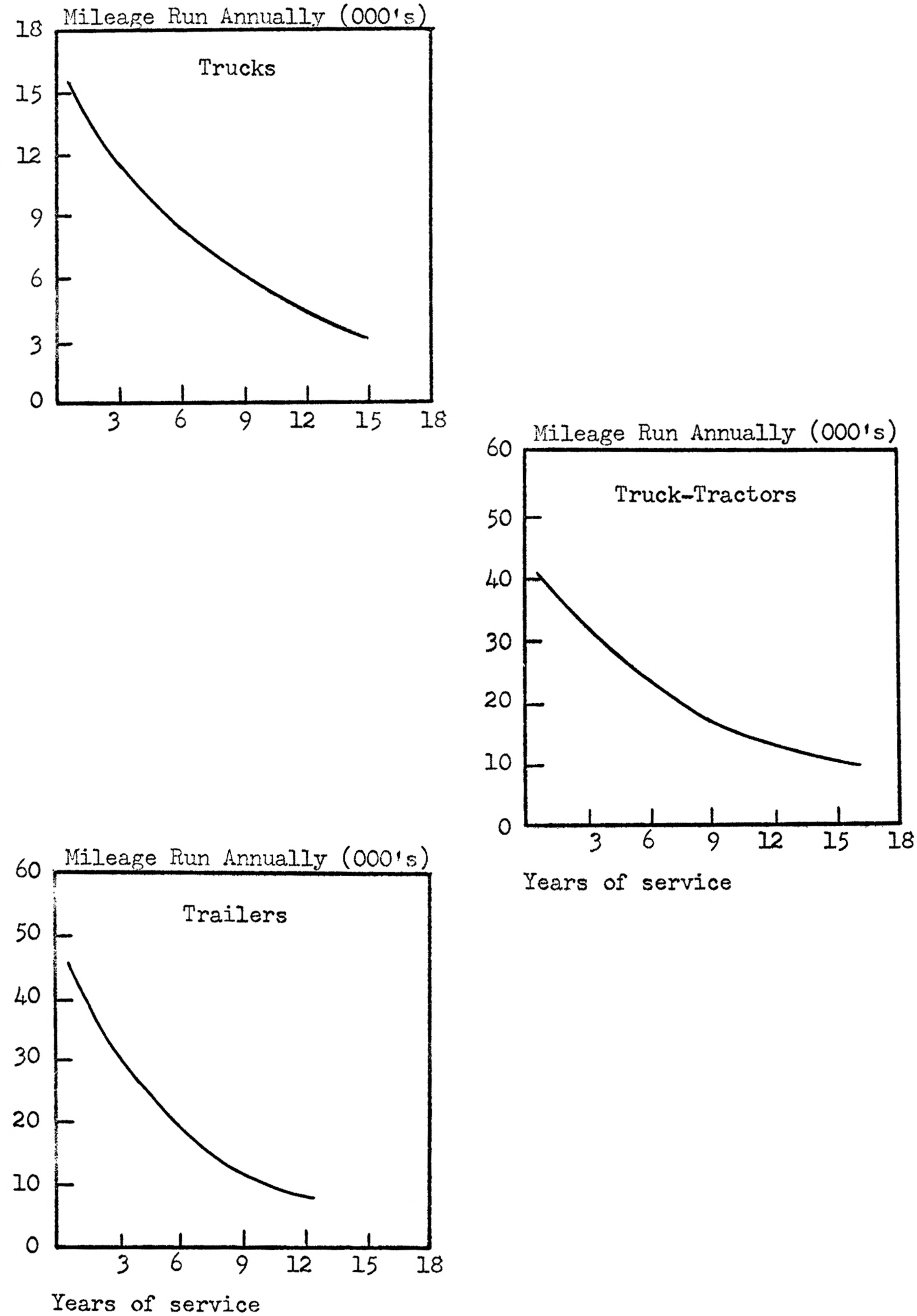

Fig. 17.--Relation between age and intensity of use for the major items comprising a feed delivery operation.

that a feed trailer's decline in productivity would be as small as five per cent.

TABLE 9

YEARLY PERCENTAGE DECLINE IN UTILIZATION[a]

Year Used	Trucks	Truck-Tractors	Trailers
2	7.14%	10.00%	16.67%
3	11.54%	11.12%	17.14%
4	10.87%	12.50%	13.79%
5	9.27%	8.93%	16.00%
6	10.22%	7.85%	14.29%

[a]Data from charts prepared by George W. Terborgh, pp. 20-21.

Depreciation

Depreciation refers to the amount an asset's value will decrease irrespective of the quality of maintenance it receives. In an economic sense, depreciation allowances enable business enterprises to keep their capital investment intact. By determining the unavoidable annual loss that a capital asset incurs, management can establish a depreciation reserve fund which will insure them when the equipment needs replacing, the money in reserve plus the scrap value of the asset, will equal the amount initially paid. Since the revised federal income tax law became effective on July 12, 1962, depreciation allowances have become more important to truck owners. The objective of the revised law is to shorten the depreciation period. This will enable feed distributors to write their carriers off at faster rates. Minimum years as stated by Internal Revenue Service are:

General-purpose trucks:
Light (actual unloaded weight less than 13,000 pounds) - 4 years
Heavy (actual unloaded weight 13,000 pounds or more) - 6 years
Tractor units (over-the-road) - 4 years
Trailers and trailer-mounted containers - 6 years[1]

A comparison of these figures with the actual number of years used by fourteen feed firms shows feed distributors generally do not depreciate their trucks as fast as the law allows. Table 10 shows the average number of years used by these firms in relation to the rated truck size.

TABLE 10

AVERAGE NUMBER OF YEARS USED BY FOURTEEN FEED MANUFACTURING FIRMS FOR FIGURING DEPRECIATION EXPENSES[a]

Truck Size	Average Number of Years	Range of Years Used	Number of Years Most Frequently Used
1-10 ton	5.08	2 - 10	4.0
11-20 ton	6.08	2 - 10	4.5
21-35 ton	5.57	4.5-10	5.0

[a]Data received for truck cost study by Leonard W. Schruben, Kansas State University.

It should be evident from this table that factors other than the legal limitations are considered when feed distributors determine the useful life of their delivery trucks. Earlier depreciation laws hampered executive decisions pertaining to re-equipment programs by setting unrealistic write off requirements. This discrepancy between useful life and economic life has been alleviated a great deal by the 1962 income tax law. As is

[1]U.S., Treasury Department, Depreciation Guidelines and Rules, Internal Revenue Service Publication No. 459 (Washington: U.S. Government Printing Office, 1962), p. 11

stated in Depreciation Guidelines and Rules, distributed by the Internal Revenue Service:

> A central objective of the new Procedure is to facilitate the adoption of depreciable lives even shorter than those set forth in the guidelines, or shorter than those currently in use, provided only that certain standards are met and that subsequent replacement practices are reasonably consistent with the tax lives claimed.[1]

It is not the purpose of this paper to elaborate on current depreciation allowances, but they have to be discussed to some extent in order that all the blaime for poor replacement policies will not be placed upon tax laws. The majority of re-equipment programs which are formulated in the manner prescribed in this thesis will not conflict with the federal regulations. If, however, delivery trucks are used so intensively they depreciate faster than tax laws permit, a sound displacement policy is still unrestricted if management can prove their case as prescribed in the fore mentioned publication.[2]

The relationship between depreciation and replacement procedures is best explained by Mr. George W. Terborgh:

> This is a fact, obviously, of the most practical consequence. It confronts the owners of these nominally "durable" but nevertheless emphemeral goods with two problems. The first is to distinguish the quick from the dead; in other words, to tell whether goods not yet physically exhausted have outlived their economic usefulness, either generally or for the particular function they perform. The second is to make financial provision against the wastage of durable assets over their service life. The one involves replacement, or re-equipment, policy; the other, depreciation policy.[3]

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[1]Depreciation Guidelines and Rules, p. 1.

[2]Depreciation Guidelines and Rules, p. 23.

[3]Terborgh, p. 1

Many volumes have been written on the subject of depreciation and the affect it has on both the total economy and the individual firm. In this text, however, it will be discussed only with reference to the influence it might have in determining the appropriate date for least-cost replacement. Terborgh is of the opinion that depreciation has two adverse affects on displacement policy.[1] Directly, management is hindered by the amount of book value the asset may hold. In many cases when all capital costs have not been recovered, officials are reluctant to trade their equipment even though an accurate cost study has indicated they should do so. Tax laws may keep companies from writing the asset off as fast as they would like. This frequently causes management to hold the capital asset until it has served the life that was set up for its depreciation pattern. Depreciation may also inhibit re-equipment decisions indirectly. Companies that use accelerated write-off systems have more opportunity for early replacement. This would seem to apply especially well to delivery firms. But, as Preinreich points out, nearly ninety per cent of the firms in the United States still use the straight line method; whereby, depreciation costs are spread equally over the life of the asset.[2] The impact of an unaccelerated write-off procedure can hamper not only individual firms but also national economies. Terborgh gives reference to this when he writes: "The extraordinary low rates of depreciation formerly taken in Britain, both for book and for tax purposes, have unquestionably contributed to the technological backwardness of industry in that country."[3]

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[1] Ibid., p. 6.

[2] Gabriel A. D. Preinreich, "The Economic Life of Industrial Equipment," Econometrica, VIII, (June, 1940), p. 13.

[3] Terborgh, p. 6.

Depreciation offers feed manufacturers a method for keeping capital intact. Management's problem is to determine how much should be charged for the truck each year and how this amount can be costed over the life of the asset. If a carrier is properly maintained and no new model is placed on the market which offers major technological advances, then depreciation corresponds to the rate of deterioration.

Since depreciation is often meant to include both deterioration and obsolescence, the latter two terms will be used throughout the remainder of this text. Deterioration and/or obsolescence are the reasons why machines have to be replaced.

A linear equation prescribed for analytically determining the amount of deterioration, D, for a given year, is given by Francois J. Olmer, as:

$$D = m + \delta t$$

with m being the first year maintenance cost, δ the average deterioration rate per year, and t the year in question. Once management is able to determine the value for δ, the amount of deterioration that can be expected is easily calculated. If it is found by analyzing internal records that the average deterioration expense is \$1500 per year and first year maintenance expense is \$1000, degeneration for a three year old truck would amount to:

$$D = \$1000 + \$1500(3)$$

$$D = \$1000 + \$4500$$

$$D = \$5500$$

Obsolescence

Obsolescence is an inherent characteristic of all capital assets. It is a type of cost that equipment cannot avoid. Even though a machine may be in perfect running order, if a similar machine is introduced that will perform the same function more efficiently, then the present piece of equipment has experienced a drop in value.

Obsolescence pertains to the function the mechanism is required to perform. A truck may prove to be obsolete for long over-the-road hauls, yet it still may prove to be a valuable asset to the company when placed in a stand-by position. The concept that obsolescence takes place only at an old age is questioned by Terborgh.[1] Vehicles which undergo an intensive use will be affected more by a new transportation innovation than will the motor carriers that are operated only sparingly.

Figure 18 prepared by Olmer, illustrates how obsolescence expense can be determined when two items have equal minimum average costs. Since the cost curves in Figure 16 were identical, C_1 can be superimposed on C_o. It is then seen that M_1 drops to M'_1. According to Olmer's concept of the free market the difference between M'_1 and M_o is made up of costs due to obsolescence.[2] Obsolescence in this case amounts to:

$$M'_1 = M_o - \lambda$$

where λ represents expense due to obsolescence.

Burton V. Dean, of Case Institute of Technology, writes that in most replacement formulas obsolescence "is either ignored or assumed to be same as in the past."[3] In models presented in this paper, obsolescence will be assumed to be a linear function of time. Various rates will be illustrated,

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[1]Terborgh, p. 28.

[2]Olmer, p. 117.

[3]Russell L. Ackoff, Progress in Operations Research (New York: John Wiley and Sons, Inc., 1961), p. 332.

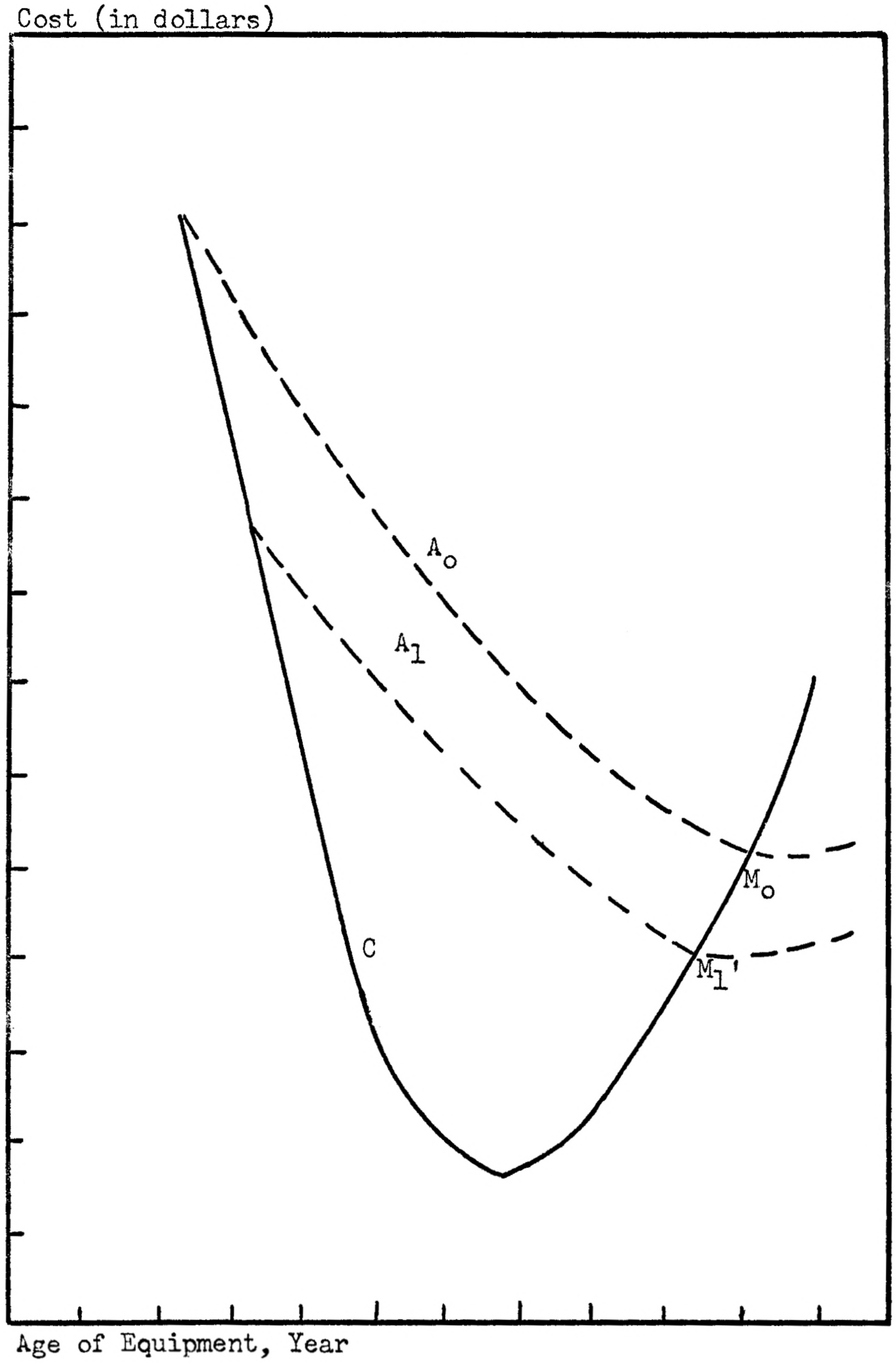

Fig. 18.--Relationship of average cost and obsolescence.[1]

[1]Olmer, p. 116.

but in actual practice management will have to predict the proper values from past experience and company records.

Salvage Value

A capital asset's value after it has completed its useful life is termed the salvage or scrap value. The difference between the terminal value and the initial outlay made for the item corresponds to the total depreciation expense.

Lewis maintains that in many cases the book value of a machine bears no relationship to its real value.[1] The particular scrap value being used may be one that was chosen only for the accountant's convenience. Even though a feed firm may be operating a delivery truck that has surpassed its write-off period, usually the company will still not sell the vehicle for the scrap value that has been used in figuring its depreciation. In other words, its inside value, or the function it performs for the firm, is worth more than the indicated salvage value.[2]

Olmer assumes that a terminal value can be set by executives when he presents his formula for computing the yearly salvage value:

$$Lt = S + \frac{C-S}{k^t}$$ [3]

Symbols in the equation represent the following:

Lt = the salvage value of a piece of equipment t years old

S = the terminal value

C = initial cost of the item

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[1] Jacob Louis Meij, _Depreciation and Replacement Policy_ (Amsterdam: North-Holland Publishing Company, 1961), p. 29.

[2] _Ibid._, p. 30.

[3] Olmer, p. 112.

K = a constant referring to decline of a capital asset.

The exponential factor, K, can be computed for a capital item by finding the natural logarithm of the value:

$$\frac{2\lambda + \delta}{C_i + \sqrt{\frac{C\delta}{2}}}$$

where λ is the amount of obsolescence, δ the level of deterioration per year, and i the rate of interest.[1] If the difference between minimum annual cost for two different motor carriers (λ) had been found to be $200, a value of $1500 was given to the deterioration gradient (δ), the initial cost was $8000 (C), and the firm used a five per cent interest rate (i) for computations, the natural logarithm (ln) for k will be:

$$\ln k = \frac{2(200) + 1500}{8000(.05) + \sqrt{\frac{8000(1500)}{2}}}$$

$$= \frac{1900}{2849.49}$$

$$= .6668$$

$$k = 1.95$$

The third year salvage value for vehicles that correspond to the above data, assuming a terminal value of $500, would be as below:

$$L_3 = 500 + \frac{8000 - 500}{1.95^3}$$

$$L_3 = \$1,512.15$$

Determining the Least-Cost Replacement Program

The validity of a truck displacement pattern depends on the accuracy of cost information maintained by the firm and the ability of its management to predict cost trends for future trucks. Replacement decisions that

[1] *Ibid.*, p. 114.

are based on re-equipment formulas are made by answering a series of questions:

(1) What truck or trucks most need replacing?

(2) What is the minimum average cost of the firm's least efficient truck or group of trucks?

(3) Of the many new, used, and rental vehicles that are available, which will offer the firm the least annual average cost?

(4) Would the less expensive replacement choice enable the company to achieve any overall cost reductions?

The following discussion will explain procedures that have been found useful for answering the above questions. The author has chosen to present these methods in a manner that would enable feed distributors to adopt a sound truck replacement program for their company.

Selecting the Truck Most Needing to be Replaced

Deciding which item should be replaced first is often a complex problem facing business managers. Feed manufacturers are included in this group because of the many capital assets that make up the normal feed plant. But since the scope of this paper has been limited to feed delivery analysis, the selection process has been greatly simplified. In most cases a firm's internal cost records will indicate which carriers are costing the most to operate. Shop foremen, in their process of recording maintenance and repair expenditures, are usually aware of the trucks that are costing a firm the most money. However, these same persons would have difficulty in determining the most economical time for replacing trucks.

Before different replacement procedures can be discussed, it must be assumed that an adequate bookkeeping system is maintained by the firm.

In the case of wholesale feed firms that operate large numbers of both bulk and sacked delivery trucks, a quick review of cost records may not identify the replacement priority. Executives of these companies will have to determine the adverse minimum for each truck in question; the method for which is discussed in the following subsection. After average costs have been determined, management may find when they are compared with the average cost of the best replacement trucks, the situation presented in Table 11 exists. Management's best decision would be to replace all three carriers, even though truck number one was still more efficient than any replacement model. This would probably occur where a truck dealer offers substantial discounts to customers that purchase more than one vehicle at a time.

TABLE 11

COMPARING MINIMUM AVERAGE ANNUAL COSTS

Truck	Minimum Average Annual Cost		Net Annual Savings
	Present	Best Alternative	
1	$ 950	$1000	$- 50
2	1500	1000	500
3	1350	1000	350
1 & 2	2200	1850	350
2 & 3	2650	1850	750
1 & 3	2000	1850	250
1, 2, & 3	3500	2600	900

In selecting the carrier to be replaced, feed distributors must not lose sight of the firm's overall operations and objectives. MAPI points out this may happen even in the most efficient companies when it writes that:

> it is well to remember that in tooling a complex process of production it is possible to have the best available machine for each separate job or function as presently set up, but nevertheless to have the entire layout replaceable as a whole.[1]

This indicates that a feed firm may have the most efficient tractor-trailer combinations available for delivering sacked feed when actually net savings could be increased by replacing all units with trucks capable of distributing bulk feed.

Net annual savings is an objective method for determining which carriers should be traded and the order in which they should be replaced. But, there are also other matters that management must remember when deciding the replacement priority. Scheuble explains these as:

> (1) Before a final selection is made, the replacement proposals should be evaluated in light of the company's future plans regarding markets, products, resources, and the general business outlook. It should be emphasized that the net savings figure is not the criterion which determines the final decision but only a valuable (perhaps the most valuable) bench mark.
>
> (2) Also entering into the replacement decision will be the comparative risk involved. Generally, those replacements with short capital recovery periods will show better net savings, thus simplifying the problem of selection. Sometimes, however, equal net savings are available from other projects with longer recovery periods. While no general rule can be established in choosing between such alternatives, the replacement with the shortest recovery period may be more desirable from the standpoint of less risk. Again, however, there is no substitute for good judgment; there are plenty of factors that can make the opposite decision the wise one.
>
> (3) Some replacements are mandatory. Usually these problems involve a decision of whether to overhaul old equipment or to buy new equipment, where failure to take action would result in loss of sales. The net savings calculation, with potential profit loss not included, might show a negative value. Since in such a case we are interested in the alternatives of major overhaul versus replacement, the proposition involving the smallest net loss may be the most desirable.[2]

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[1] MAPI Replacement Manual, p. 35.

[2] Scheuble, pp. 90-91.

Assuming feed distributors are able to select their least efficient carrier or group of carriers by reviewing internal cost records, their next step is to determine which replacement alternative would best serve their firm.

Selecting the Best Available Replacement Model

Selecting the least-cost alternative is just as important as determining the least efficient truck the firm is now operating. As stated in the MAPI Replacement Manual, "an analysis of the right defender and the wrong challenger will yield . . . the right answer to the wrong problem."[1]

A thorough review of all available motor trucks is necessary before the best challenger can be chosen. Usually the best sources of information are the various truck manufacturers. After relating the potential advantages to the different acquisition costs, feed distributors can generally identify the vehicle that would be the most economical for their firm. In cases where this is not so clear, replacement formulas can be applied to the various alternatives. The next section will explain procedure for using re-equipment equations.

Probably the most important item that should be considered when choosing a challenger is the number of years it will be able to serve the firm. A full discussion of the method in which service life is computed is also delayed until the next section in the interest of space and simplicity.

After choosing the defender and challenger, management must then compare the two in order to determine whether or not replacement is economical at this time.

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[1]MAPI Replacement Manual, p. 45.

Computing the Minimum Average Annual Costs for the Selected Defender and Challenger

Operations Research Formulas. - The basic principles involved in making truck costs comparisons can best be explained by first presenting the so called short cut re-equipment equations. Once the underlying replacement concepts are understood, the more advanced MAPI and Olmer formulas can be easily comprehended.

Sasieni, Yaspan, and Friedman present a simplified method for determining the least average annual cost where only one truck is in question.[1] They assume management can accurately predict the annual rate at which maintenance and repair costs will increase and the yearly decline in capital expense. Although this procedure leaves a great deal to be desired, it does offer fleet owners an easy method for quickly estimating the period a truck will reach its minimum average cost. If, for example, a new truck retailed for $8000; decreased fifty per cent in value each year it was used, until it was worth $200; and cost $1000 the first year and an added $500 each additional year for maintenance and repair; a feed distributor could determine its annual average cost and the year that it would reach its minimum average annual cost by following the procedure in Table 12.

In the table the annual cost for owning and operating the $8000 truck would be lowest during the sixth year. The sixth year is the most economical year for replacement only if it is assumed that the best alternative will have identical cost characteristics. This would be ignoring the effect of technological achievement.

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[1]Maurice Sasieni, Arthur Yaspan, and Lawrence Friedman, Operations Research Methods and Problems (New York: John Wiley and Sons, Inc., 1959), p. 103.

TABLE 12

ANNUAL AVERAGE COST FOR ONE TRUCK[a]

(1) Year	(2) Annual Maintenance and Repair Cost	(3) Column 2 Accumulated	(4) Resale Value	(5) Total Capital Cost (Initial Cost-Col 4)	(6) Total Cost (Col 2 + Col 5)	(7) Annual Average Cost
1	1000	1000	4000	4000	5000	5000
2	1500	2500	2000	6000	8500	4250
3	2000	4500	1000	7000	11500	3833
4	2500	7000	500	7500	14500	3625
5	3000	10000	200	7800	17800	3560
6	3500	13500	200	7800	21300	3550
7	4000	17500	200	7800	25300	3614

[a]Sasieni, Yaspan, and Friedman, p. 104.

Discounting is another factor that is left unconsidered in this example. Churchman, Ackoff, and Arnoff point out how discounting procedures are used and misused when they write:

> Since costs are incurred over a period of time, and since money has a value over time, the use of neither the minimum of a sum of undiscounted costs nor the minimum of average discounted costs over the period between replacements is satisfactory.[1]

Although the following table departs from our single truck model, it illustrates the fact that undiscounted costs are likely to give incorrect information.

TABLE 13

TWO COST PATTERNS[a]

	Cost at Beginning of Year, Dollars		Discounted Cost (10% Rate), Dollars*	
Year	Machine 1	Machine 2	Machine 1	Machine 2
1	900	1400	900.00	1400.00
2	600	100	545.45	90.91
3	700	700	578.52	578.52
Total	2200	2200	2023.97	2069.43
Difference	0		45.46	

Churchman, Ackoff, and Arnoff, p. 483.

The discounted cost is the present value of the cost, and is obtained by the expression $Cn/(1+r)^{n-1}$, in which Cn is the cost at the beginning of the nth year, r is the annual discount rate (worth of money), and n is the number of years.

Discounting affords management a method for determining what the present value of a cost outlay will be in n years. It is generally

[1]Churchman, Ackoff, and Arnoff, p. 482.

assumed that a dollar today will not be worth the same amount a year later. If it were discounted at four per cent for one year, it would have a present value of only ninety-six cents. As shown by Flagle, Huggins, and Roy, the present value of a truck and its yearly running costs can be easily computed by considering them a function of the frequency of replacement.[1] Assuming the same cost and price conditions that were presented in Table 13 and a five per cent discount rate, the cost for replacing the truck each year, every two years and every three years could be found by applying the formula:

$$A + \frac{C_2}{1+r} + \frac{C_3}{(1+r)^2} + \frac{C_4}{(1+r)^3} + \ldots + \frac{C_n}{(1+r)^{n-1}}\left[\frac{1}{1-\frac{1}{(1+r)^n}}\right]$$

where A = initial purchase price plus first year maintenance cost

C_i= repair and maintenance costs incurred for that period

r = rate of interest

n = the specific year

Cost for replacing each year:

$$9000\left[\frac{1}{1-\frac{1}{1.05}}\right]$$

$$= 9000(21.0084)$$

$$= \$189,075.60$$

Every two years:

$$9000 + \frac{1500}{1.05}\left[\frac{1}{1-\frac{1}{1.05^2}}\right]$$

Every three years:

---

[1]Charles D. Flagle, William H. Huggins, and Robert H. Roy, Operations Research and Systems Engineering (Baltimore: The John Hopkins Press, 1960), p. 212.

$$9000 + \frac{1500}{1.05} + \frac{2000}{(1.05)^2}\left[\frac{1}{1-\frac{1}{(1.05)^3}}\right]$$

$$= 12,243(7.3421)$$

$$= \$89,889.33$$

Applying this formula to the fourth, fifth, sixth, and seventh years, the respective values would be: \$81,234, \$77,963, \$77,309, and \$78,112. In this situation replacement should take place every six years. By using this discounting method, management is able to determine the amount of capital that would presently be needed to replace their truck at the specified period; assuming money is discounted at five per cent annually.

It is clear from the above example that when discounting is introduced the most economical replacement pattern may be changed. Improper use of discounting procedures, however, may cause executives to make incorrect decisions. As pointed out by Churchman, Ackoff, and Arnoff, when two capital items are compared, the one with the lowest average discounted value may not be the best buy.[1] The assets must be considered over equal time periods.

For example, when gasoline and diesel powered trucks are compared, the former has the lowest purchase price and shortest economic life, but its annual repair and maintenance expense will be the highest. The present value of the predicted expenditures for the different type motor trucks may be derived in the following manner:

---

[1]Churchman, Ackoff, and Arnoff, p. 482.

	Gasoline Powered Truck	Diesel Powered Truck
Purchase Price	$6000	$9000
Cost First Year	1500	1000
Cost Second Year	3000	2000
Cost Third Year	4500	3000
Cost Fourth Year		4000
Cost Fifth Year		5000
Cost Sixth Year		6000

Discounted value of the gasoline fueled carrier would be:

$$7500 + \frac{3000}{1.05} + \frac{4500}{1.05^2} = \$14{,}439$$ [1]

Or the annual discounted cost per year would be $4813. The discounted value for the longer lived but more expensive diesel powered truck would be:

$$10{,}000 + \frac{2000}{1.05} + \frac{3000}{1.05^2} + \frac{4000}{1.05^3} + \frac{5000}{1.05^4} + \frac{6000}{1.05^5} = \$26{,}895.89$$

The annual charge in this case would be $4483. It would appear from this comparison that the diesel truck would save the firm nearly $400 a year. However, since the gasoline truck was discounted over only a three year period its computed average annual cost is incorrect. The proper method would be to derive annual cost over a six year term as in the following example:

$$7500 + \frac{3000}{1.05} + \frac{4500}{1.05^2} + \frac{7500}{1.05^3} + \frac{3000}{1.05^4} + \frac{4500}{1.05^5} = \$26{,}911 \text{ or } \$4485 \text{ per year}$$

---

[1]This discounting method differs from the one used by Flagle, Huggins, and Roy by the factor: $\left[\frac{1}{1-\frac{1}{(1+r)^n}}\right]$ Their method indicates the present value, if management is going to replace their truck at specified yearly intervals from now until infinity. Churchman, Ackoff, and Arnoff show what the present value is, if the vehicle is traded in a certain number of years.

Now it can be seen that instead of a $400 annual difference the actual yearly variation is only two dollars. In which case the firm would be largely indifferent as to which truck they purchased.

Table 14 illustrates the method prescribed in Introduction to Operations Research.[1] Like the previous example, this procedure is based on the assumption that the period of minimum weighted average cost is the period in which equipment should be replaced. The authors who formulated this procedure state two rules for minimizing replacement cost:

> (1) do not replace if the next period's cost is less than the weighted average of the previous cost.
>
> (2) replace if the next period's cost is greater than the weighted average of previous costs.[2]

The sixth year in Table 14 would fulfill these qualifications.

The previous formulas for determining optimum replacement periods are sometimes referred to as "short cuts" or "dodges."[3] This is because they depend entirely on the values of the minimum average costs. The more advanced MAPI formula allows management to evaluate additional cost advantages such as labor, capacity, fuel, and major overhauls.

Machinery and Allied Products Institute Formula. - The Company Procedural Manual on Equipment Analysis, edited by MAPI offers the most complete information pertaining to the procedure a company should follow when adopting a replacement program.[4] Since their method has been tested and proven effective for such firms as: The Allis-Chalmers Manufacturing

---

[1] Churchman, Ackoff, and Arnoff, p. 488.

[2] Ibid., p. 486.

[3] Terborgh, p. 176.

[4] Company Procedural Manual, p. 15.

TABLE 14

REPLACEMENT COSTS[a]
($A = 8000$, $r = 0.05$)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	Annual Maintenance and Repair Costs (C_i)	Discount Factor $X^{i-1} = \left(\frac{1}{1+r}\right)^{i-1}$	$C_i X^{i-1}$	$A + \Sigma C_i X^{i-1}$	ΣX^{i-1}	Average Weighted Cost $\frac{A + \Sigma C_i X^{i-1}}{\Sigma X^{i-1}} = (1-X)Kn$
1	1000	1.0000	1000	9000	1.0000	9000
2	1500	.9524	1429	10429	1.9524	5342
3	2000	.9070	1814	12243	2.8594	4282
4	2500	.8638	2159	14402	3.7232	3868
5	3000	.8227	2468	16870	4.5459	3711
6	3500	.7835	2742	19612	5.3294	3680 - Replace
7	4000	.7462	2985	22597	6.0756	3719
8	4500	.7107	3198	25795	6.7863	3801

Column (1): Number of elapsed periods
Column (2): Cost incurred in each period
Column (3): Discount factor applicable in the respective period
Column (4): Cost in each period, discounted to the beginning of period one
Column (5): Accumulation of column (4)
Column (6): Accumulation of column (3)
Column (7): Ratio of column (5) to column (6)

[a]Churchman, Ackoff, and Arnoff, p. 488.

Company, American Locomotive Company, Clearing Machine Corporation, Cooper-Bessemer Corporation, Draper Corporation, Illinois Tool Works and Shakeproof, Inc. Division, Jones and Lamson Machine Company, Nordberg Manufacturing Company, Sundstrand Machine Tool Company, Universal Winding Company, and Worthington Pump and Machinery Corporation; it was felt that much of the technique could also be applied to feed truck replacement decisions.[1]

The Replacement Analysis Chart for Feed Delivery Trucks, illustrated in Figure 19, shows how the MAPI method may be applied to a feed delivery operation. By understanding how each of the items are computed in this chart, feed distributors will be able to adopt this procedure for their own firm. Both the truck on hand and the replacement alternative are compared in this table and it was felt that it would be better to discuss both sides of the replacement question at the same time. In explaining the chart, formulas other than those prescribed by the MAPI are discussed in order that managers will have at their disposal all of the proven replacement equations. One method may be used to check another method or a company's data might be better fitted for one equation than it is for another.

By following the assumptions that were previously discussed, the items necessary for the Replacement Analysis Chart for Feed Delivery Trucks are obtained in the following manner:

Line 1. Description: (A)

(a), (b), & (c). These items are required so the defender will be properly identified. This becomes more important as the number of trucks

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[1] *Ibid.*, p. 5.

Date 13/12/63

Truck(s) On Hand (A)	Replacement Alternative(s) (B)
1. Description:	1. Description:
(a) make(s) . . 1960 12-Ton IHC	(a) make(s). . 1963 12-Ton Mack
(b) date purchased. . . . 1960	(b) cost $9000
(c) purchase price. . . . $8000	(c) initial use. . . . . Over-the-road-hauls
(d) future use. . . . . . sale	(d) primary service life . . . . 5 years
(e) salvage value $1437	(e) scrap value. $500

Operational Comparisons (Income & Cost)	Total	A Advantage	Total	B Advantage
2. Income Advantages:				
(a) miles per month @ $0.01 per mile	$ 552		$ 600	$ 48
(b) capacity per truck @ $0.50 per ton	300		300	
(c) additional customers	000		500	500
(d) overall company objectives	000		000	
(e) backhauls	000		120	120
(f) other				
3. Costs Advantages:				
(a) miles per gallon of fuel (20¢ per gallon)	2143	$257	2400	
(b) labor, direct	3600		3600	
(c) labor, indirect	250		100	150
(d) garage supplies	210		90	120
(e) taxes and tolls	150	10	160	
(f) insurance	200		200	

(g) oil and grease	180		110	70
(h) ordinary maintenance	200		100	100
(i) major repairs	150		000	150
(j) tires	120		108	12
(k) other				
4. Totals		267		1275
5. Economic advantage replacement alternative offers (4B-4A)				$1010

	A's Minimum Average Annual Cost	B's Minimum Average Annual Cost
6.	Operating inferiority (Line 5) $1010	Purchase price (Line 1bB). . $9000
7.	Salvage value that will be lost next year. $466	Service life (Line 1dB). . . 5 years
8.	Required rate of return 5% x (Line A-1d). $72	Final scrap value. $500
9.	Capital additions Total $500	Salvage as per cent of initial cost (8B of 6B). 5.55%
10.	Next year proration . . . $250	Interest @ 5%+ Chart per cent 34
11.	Required rate of return 5% x (Line 9A). $250	Interest per cent x Purchase price (10B x 6B) $3060
12.	Total omitting Line 8 =	Predicted Annual Average Capital Additions. $100
13.	Minimum Average Cost . . $2048	Minimum Average Cost (12B + 11B) = ... $3160
14.	Gain that could be made next year by replacing A with B (13A-13B. . $-1076	

Fig. 19.--Replacement analysis chart for feed delivery trucks.[1]

[1]Chart was patterned after MAPI's "Re-Equipment Analysis and Operational Work Sheet" presented in their text, Company Procedural Manual On Equipment Analysis, William Kelly and Company, March, 1951, p. 15.

being considered increases. Future use explains what the vehicle will be used for if it is found that it should be replaced.

(d). As pointed out in the second section of this chapter, salvage values decrease at an exponential rate each year until the terminal value is reached. After a truck has reached its terminal or scrap value, the salvage value is unimportant in replacement equations. By assigning K an arbitrary value of two dollars and assuming a terminal value, S, of $500 the current value (L) of the truck described in the chart would be computed as follows:[1]

$$L_3 = 500 + \frac{8000 - 500}{2^3}$$

$$= \$1437$$

This follows from the formula presented by Olmer.[2]

(B)

(a), (b), & (c). Besides using the first two spaces for make and cost of the best available replacement, managers may also indicate the second and third alternates. This will offer future reference if some item changes that would increase the expense of the first choice. Initial use refers to the specific function for which the challenger is being compared. MAPI indicates that management should be only concerned with the primary use and all subsequent uses should be completely disregarded.[3]

(d). An accurate estimate of economic life is of utmost importance in computing the challenger's adverse minimum. As will be shown later,

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[1]The value two was given to K, due to the fact a feed truck's resale value declines approximately fifty per cent each year.

[2]Olmer, p. 112.

[3]<u>Company Procedural Manual</u>, p. 19.

the validity of the MAPI formula depends directly on the predicted service life. Olmer has proven his equation for determining economic life:

$$t = -\frac{2}{B}\ln\frac{B}{2i}\left[\sqrt{1+\frac{4\delta i}{CB^3}}-1\right]$$

which is based on the logarithmic function of an asset's salvage value, to be very effective.[1] Table 15 shows the amount of error Olmer found

TABLE 15

CALCULATED AND TRUE VALUES OF ECONOMIC LIFE[a]

i	δ$	Economic life	
		True years	Calculated years
.05	50	13	14
	100	6	7
	150	3	4
.10	50	13	14
	75	9	10
	100	7	8
	150	4	4
.20	50	14	15
	100	9	9
	150	6	6
.30	50	15	16
	100	10	10
	150	7	7

[a]Olmer, p. 121.

[1]Olmer, p. 121.

when he applied his formula to items with known service lives. Out of his thirteen estimates, more than one third corresponded to the true age and no prediction varied from the actual life by more than one year.

If the challenger in this example retailed for $9000, deteriorated rate of $2000 annually, discounted at the rate of five per cent, and obsolescence cost averaged $200 per year, then its economic life (t) could be computed as below:

$$\ln K = B = \frac{2\lambda + \delta}{C_i + \sqrt{\frac{C\delta}{2}}}$$

$$= \frac{2(200) + 2000}{9000(.05) + \sqrt{\frac{(9000)(2000)}{2}}}$$

$$= .6956$$

$$t = -\frac{2}{.6956} \ln \frac{.6956}{2(.05)} \left[\sqrt{1 + \frac{4(2000)(.05)}{9000(.6956)^3}} - 1\right]$$

$$= -2.87 \ln .4451$$

$$= 5.19 \text{ years}$$

(e). This value should represent the actual amount company officials contemplate receiving for the motor truck when it is sold at the end of its economic life. Since there is relatively little fluctuation in used truck prices, feed truck owners should have no difficulty in predicting a delivery truck's terminal value. The scrap value in this example is the same as it is for the defender.

Line 2. Income Advantages: (A) & (B)

(a). Review of delivery records will provide needed information as to the number of extra miles a new truck will offer a firm. The least that could be expected from the new model would be that it could be driven as many miles as the present truck was when it was new. Claims of additional mileage by sources outside the firm should, however, be closely scrutinized.

If it is shown on the defending carrier's service record that it was driven an average of 5000 miles per month during its first year of operation, and three years later it averaged only 4600 miles per month, then management could expect the challenger to potentially add 4800 miles to next year's delivery operation. The new truck would yield the firm an additional forty-eight dollars during the next year's operation, assuming company officials placed a value of only one cent on miles driven.

(b). Increased capacity may come in different forms. Engineering specifications may allow for more tonnage; or if truck beds are changed, the newer model may offer more compartments. Since, however, this case involves only the truck chassis and the vehicles are of the same rated size, it can be supposed that there is no income advantage due to increased capacity. Six hundred tons per month have been assumed for each truck at a rate of fifty cents per unit above average delivery cost of two dollars per ton.

(c). Management can reasonably estimate how many additional customers they can achieve by owning a more dependable truck. Sales personnel will provide valuable information in this area. Unless future customers have actually agreed to buy the firm's product, an overly optimistic estimate should be avoided at this point, however. In this example it is presumed a feeder has stated he will purchase 100 tons of feed if the company will deliver it to his farm. If the firm makes five dollars profit on each ton of feed, the new trucks being able to serve the prospective feeder would provide an additional $500 of revenue.

(d). When the replacement model is similar to the defender, a business's officials are usually not altering their overall objectives. A feed manufacturer who is changing to bulk delivery may actually show negative figures in 2.(a) & (b). If so, additional customers and company objectives will have to offer substantial gains to make the replacement economical. There does not seem to be a change in company policy in this case, so no income advantage is indicated.

(e). Added backhauls should be considered in the same manner as future customers. As pointed out in the previous chapter, backhauls are of major importance; and if an obsolete motor carrier is reducing a firm's backhaul potential, it should be considered for replacement. Backhaul has been assumed to increase ten dollars per month in this example.

Line 3. Costs Advantages:

Company officials can accurately forecast cost advantages by inspecting cost records and familiarizing themselves with technological advances. Arbitrary values have been assigned these entries and only a few of them warrant special discussion.

(a). A review of cost records of one feed delivery firm which operates several ten and twelve ton trucks showed that miles driven per gallon of fuel decreased approximately two tenths a mile for each year's new model. To show the true fuel cost advantage, trucks must be considered to be driven an equal number of miles. For this example, 60,000 miles was used for the comparison basis. The defender's and challenger's fuel cost was computed by considering an average of 5.6 and 5.0 miles per gallon respectively.

(c). A motor truck requires a certain amount of office and clerical expense each year. This tends to increase, however, as the vehicle deteriorates. In addition to requiring more accounting entries, the supervisory personnel will also have to give it more attention.

Line 7-A. Salvage Value That Will Be Lost Next Year:

The method used in determining A-1d is extended an extra year to find the next year's salvage value. If the vehicle on hand is replaced this year, it will lose \$1437 - \$969 = \$466.

Line 9-A. Capital Additions:

Major overhauls many times add value to a truck that extends for more than one year. The capital value added by giving a motor carrier a \$500 overhaul cannot all be prorated to the year in which the overhaul occurred.

Line 10-B. Interest @ Five Per Cent + Chart Per Cent:

Figure 20 illustrates the chart developed by MAPI for determining challenger's adverse minimum.[1] Adequate instructions are given for manipulating the chart. In this example the chart gave a final figure of twenty-nine per cent. This was added to the rate of interest which gave a total percentage figure of thirty-four. Thirty-four per cent of the retail price, \$9000, yields \$3060.

When final tabulations are made, it is found that the firm would lose nearly \$1000 if their present truck was replaced at this time.

This chart was developed by MAPI analysts in order that the replacement procedure would be simplified. The actual formula as given in the MAPI Replacement Manual (Washington D.C.: Machinery and Allied Products Institute, 1950), p. 71, is:

$$\text{Adverse minimum} = \frac{in(ci+rsp)-s(i+r)(1-p)}{in+p-1}$$

where: c = the acquisition cost
n = the service life
s = the terminal salvage value
i = the interest rate in decimals
r = a symbol for $\frac{2.30259}{n}(\log c - \log s)$
p = the present worth factor for the service life and interest rate indicated.

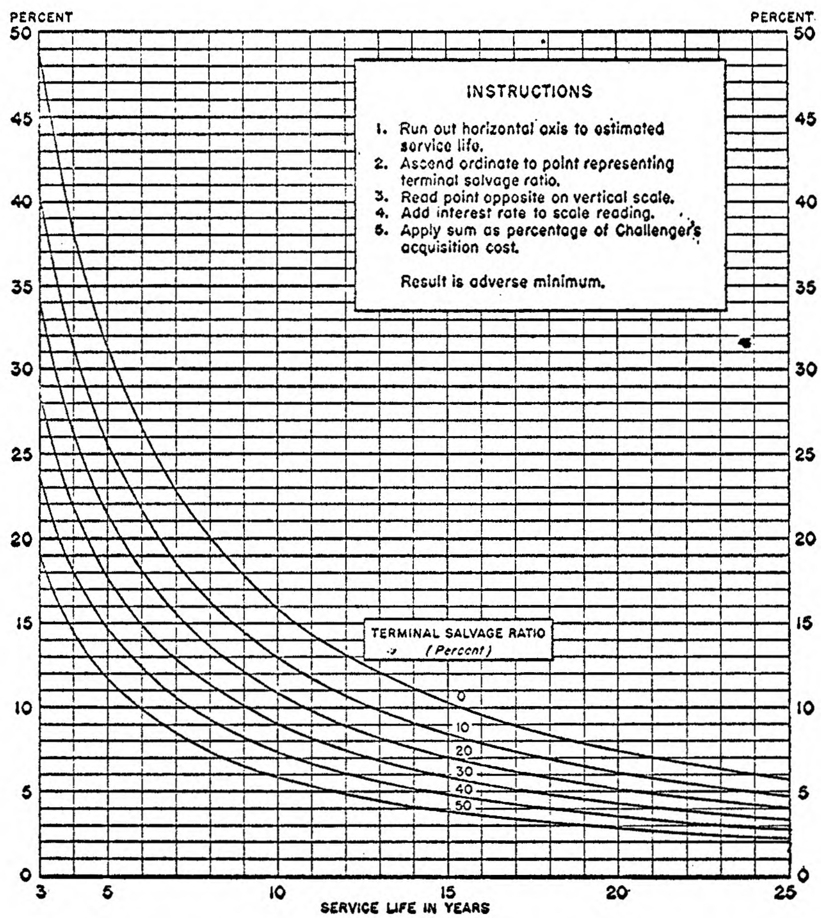

Fig. 20.--Chart for deriving challenger's adverse minimum by the MAPI formula.[1]

[1]MAPI Replacement Manual, Machinery and Allied Products Institute, 1950 (Inside of back cover).

Replacement Program and Company Organization

The establishment of a re-equipment policy is a company, rather than a departmental, function. Equipment replacement is only one of many problems facing feed distributors, and it must be considered in its proper perspective. An inadequate motor truck displacement pattern will inhibit an entire feed production operation. Replacements at too narrow intervals will require unnecessary capital outlays due to high acquisition expense. A rotation pattern that replaces trucks long after they have reached their minimum average annual cost will acquire the company avoidable maintenance, repair, and down-time expenses.

Members from all organizational levels of a feed manufacturing firm are involved in the final replacement decision. This is explained by Scheuble when he writes:

> An equipment replacement program and the analysis involved require a two-way communication between top management and the manufacturing organization, as well as with other functions, such as sales, accounting, and product engineering.[1]

Scheuble is evidently referring to a type of business organization that is much larger than the average feed producing firm. This being especially true at the local dealer level. However, the size of operation does not hinder a replacement program.

Managers of large feed producing firms that are owned and operated by many different individuals have difficulty in convincing all concerned that a replacement is necessary. The person who owns and manages a smaller firm has only himself to persuade; but he also experiences problems in keeping informed of current technological advances and abnormal

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[1]Scheuble, p. 93.

truck expenses. Generally though, management of the various sized organizations will experience similar complications in regard to replacement determination.

The MAPI Replacement Manual points out that whoever is in charge of company re-equipment program should:

> start with a sound analytical technique . . . keep in touch with new developments in . . . productive technology, through trade journals, equipment salesmen, catalogs, and other sources . . . watch developments in the plant that may indicate re-equipment opportunities, such as changes in the product or the scale of operations, new labor rates, inspection rejects, scrap reports, last bids, variances from cost estimates, maintenance expenditures, breakdowns, etc. Above all [they should] enjoy the confidence and cooperation of the operating executives, who are in a position to furnish innumerable leads and suggestions for investigations. [If they] use all of these leads intelligently, and have sufficient time to pursue them, [they] should be able to keep a running inventory of currently available re-equipment opportunities.[1]

The first indication of needed truck replacement usually comes from the repair and maintenance records. This again relates the usefulness of a cost control system to the type of records that are maintained. Feed companies that are large enough to operate their own garage facilities will usually have a shop foreman. He may well be the first to notice a truck that is incurring abnormal running expenses. This information is then usually relayed to a department head. If no one is specifically assigned to analyze replacement problems, the official in charge of the delivery section should apply the appropriate re-equipment formula to determine if replacement is necessary. Supposing replacement is necessary, the department head should send his information to the general manager who will make the final decision. The top executive will receive similar requests from the production section, sales department, warehouse divi-

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[1]MAPI Replacement Manual, pp. 23-24.

sion, etc. After all applications are reviewed, they will be fulfilled with capital the firm has available for such purposes. Obviously the replacement offering the firm the most savings will be the first carried out.

Managers of smaller firms will not follow as formal a process as described above, but they will also have to decide which replacements are the most needed. As previously stated, the establishment of a re-equipment policy is a company, rather than a departmental, function.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The delivery department of feed producing firms has become more important due to the introduction of modern bulk delivery systems and the recent demand for sacked concentrates. As the delivery section becomes more important, its position as a cost center also grows more prominent.

Break-even analysis offers delivery firms a method for holding their delivery costs to a minimum. The rigid assumptions that must be made in applying this type of analysis do not appear to eliminate its use from feed delivery firms. Previous truck delivery studies which have been made have found that over the short-run period, delivery costs can be considered a linear function of time and distance. The two standards - tons and miles - were combined into a single unit so as to simplify the break-even process.

Feed distributors can employ break-even analysis to determine the rate they must charge for delivering feed to just meet expenses. Fixed and variable costs per revenue-ton-mile can be derived by either algebra or geometry. Once the company officials know what the total cost will be for delivering feed over a specified period, they can construct an income line to determine what rate must be charged for each unit delivered in order to break even.

Cost-volume-profit analysis also enables feed manufacturers to decide how much loss or profit they will absorb from their delivery service before the specified period has ended. By knowing what their costs have been and how much revenue they have derived from delivery, officials of feed producing companies know approximately how far they are from the break-even point. The ability of break-even analysis to depict a firm's distance ("danger area") from its break-even point is often stated to be its major asset.

The effects of varying delivery rates, volumes, and variable costs can also be studied by means of cost-volume-profit analysis.

While this type of analysis is restricted by severe assumptions, it still affords management needed information. Even the opponents of this simplified method of cost control admit that the procedure seems to possess some "unknown" qualities.

Replacement theory affords feed distributors another type of cost control. Its objective is to determine the most economical time for truck replacement. By so doing, the firm is able to operate only the least-cost vehicles. In this manner, feed firms can minimize their capital and operating expenses for delivering feed.

The orthodox or classical replacement formulas rely mostly on the variables: service life, obsolescence, deterioration, acquisition cost, and salvage value. Equations of this type are used to determine the minimum average annual cost for various replacement alternatives.

The Machinery and Allied Products Institute has developed the most tested replacement formula. It is also primarily based on the same variables as the short - cut methods. The method prescribed for feed truck replacement was centered mainly around the MAPI procedure. However the author inserted other formulas, especially those presented by Dr. Francois J. Olmer, where it was felt they were more applicable to feed delivery operations.

Replacement methods and break-even analysis both require accurate truck cost data. Neither method can be any more valid than the information used in its computations. Feed distributors who implement these cost control methods will receive additional benefits from the costs records that are required to be maintained.

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PROCEDURES FOR APPLYING BREAK-EVEN ANALYSIS AND REPLACEMENT THEORY TO FEED DELIVERY OPERATIONS

by

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Delivery operations have become more important to feed manufacturers since the demand for bulk feed and feed concentrates has increased during the last decade. The purpose of this thesis was to develop two procedures - one that would enable feed distributors to apply break-even analysis to their delivery operations and one that would explain how firms concerned with feed delivery can incorporate replacement theory into their truck displacement decisions. Adoption of these procedures will assist feed producers in their efforts to minimize delivery costs.

Data received from fourteen feed manufacturing firms, an interview with the president of a large feed producing company, studies made in other industries where distribution is a major cost item, and periodicals and books pertaining to the formula feed industry were used as sources of information for the writing of this thesis.

Break-even analysis offers feed distributors a method for comparing delivery costs, revenue, profits, and volume. In this case it was explained with major emphasis in the area of cost control. Both geometric and algebraic procedures were developed whereby executives could follow a step by step pattern in adopting the cost-volume-profit analysis.

A revenue-ton-mile cost basis was developed in order that feed distributors could receive the maximum benefits from break-even analysis. This standard indicates the number of miles feed is actually hauled and the distance delivery trucks are driven at less than full capacity. Information of this type is essential in correlating delivery expense and volume.

The thesis shows how cost-volume-profit analysis can be applied to feed delivery operations in both the traditional graphic form and the more advanced tabular and short-equation model. The "least-squares" method offers a precise system for separating fixed and variable delivery expenses. When costs are divided into their rigid and variable components, the procedures presented by applying break-even analysis can be easily followed.

The chief advantage break-even analysis offers officials concerned with cost control is its depiction of the area prior to the point where revenue equals profit. By knowing the position of revenue in relation to cost, management is forewarned of the profit or loss their firm will incur at the end of the fiscal period.

Replacement theory is based on the cost information, and its validity rests on the accuracy of the expense records. The re-equipment procedure presented in the thesis offers feed distributors a system for determining at what period a truck's capital and operating expenses have reached such a level that the vehicle should be replaced.

Operation Research systems and the replacement procedure developed by the Machinery and Allied Products Institute are adapted to feed delivery operations. By implementing these methods and inserting additional re-equipment equations that are better suited for feed delivery trucks, managers of formula feed firms can be assured that they are not incurring avoidable expenses due to truck depreciation, obsolescence, service life, acquisition cost, and salvage value.

The displacement system developed in this thesis explains the replacement items which should be examined and lists them in the order they should be reviewed: (1) selecting the truck most needing to be replaced; (2) selecting the best available replacement model; and (3) computing the minimum average annual costs for the selected defender and challenger.